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MANUAL OF HYDROLOGY

WITH

HYDRAULIC AND OTHER TABLES.

MANUAL OF HYDROLOGY:

CONTAINING

I.—HYDRAULIC AND OTHER TABLES.

II.—RIVERS, FLOW OF WATER, SPRINGS, WELLS, AND PERCOLATION.

III.—TIDES, ESTUARIES, AND TIDAL RIVERS.

IV.—RAINFALL AND EVAPORATION.

BY

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CIVIL ENGINEER.

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PREFACE.

THE work now laid before the public has arisen out of a small treatise called "Hydraulic Tables," published in May, 1850; of which a second edition, in a very much extended form, was issued in September, 1851. The prevailing idea of these works is described in the following extracts.

First Edition, May, 1850.—"In the computation of hydraulic questions daily required by an Engineer, much labour is saved by the systematic use of Tables; the means of detecting errors are far greater than in isolated calculations; and the results, when tabulated, are more useful than any mere formula: the one shews the object attained—the other gives the means only.

"In the following treatise the author has endeavoured to extend the basis of hydraulic calculations, on which there should not be much difference of opinion, to systematic results; the Tables are reduced to uniform measurements throughout, and the range of computations for slopes, velocities, &c., is such as will be required in practice; the whole being expressed in decimal measures.

"To these are added the general qualities of materials, with computations for the strength of iron beams of approved proportions, concluding with Tables of Numbers, &c., generally required in a treatise intended for ordinary use of the Practical Engineer. The powers, roots, and logarithms of numbers are appended in a simple and legible form, to save the labour of searching them from different works in the numerous requirements of the profession.

"The computations of all the principal Tables are original, and have taken much time and labour. It would be scarcely possible to enumerate all the authorities; among others consulted are—Du Buât, Robison, Leslie, Bossut, D'Aubuisson, Rennie, &c.; without previous researches, it would be useless to attempt a treatise of this kind, and therefore, probably, the suggestions of many have been useful, although not specifically acknowledged.

"The leading object has been to induce a more general and systematic application of hydraulic formulæ to practice: for the principles, being subject to the laws of gravity, must be uniform; therefore, however varying the means and circumstances, the results should be consistent.

"The remarks upon rainfall and the produce of springs have been made rather to give examples than to propound any particular theory."

From Preface to Second Edition, September, 1851.—"The First Edition of this work was received with much greater favour than the author had at all expected; and, by the kindness of his friends, the sale was large for so technical a work. This will be the best excuse for the new form in which the book is offered. To extend the use of this edition as a handbook for the Engineer, in matters relating to Hydraulics and Hydrodynamics, many new Tables have been constructed, and the Table of Constants for time and height of high water and mean spring range has been inscribed from the Admiralty Tables and various other sources.

"The introductory remarks on the use of the Tables have been amended, and more information is interwoven, chiefly on our English rivers. The original remarks on tides and rivers are limited, or otherwise we should have been traveling out of the scope of this treatise; experience and practice are the great guide; and, therefore, to obtain the best data for practical results, we have carefully collated all the well-authenticated data within our reach or personal experience, and had them condensed into tabular forms. The author has to thank several professional friends—Messrs. Cubitt, Rendel,

Rennie, Simpson, &c.—for their kind assistance in permitting the use of, and communicating original papers. He has also to acknowledge accessible information at the disposal of Admiral Sir F. Beaufort, F.R.S., Captain Drinkwater Bethune, and Captain Vetch, of the Admiralty Harbour department, whose published reports contain good data—not omitting to mention Captain Beechey's very valuable published papers: others to whom we are indebted are named especially when the information is due to them.

"Considering the small extent of engineering literature, and the immense stores of knowledge constantly accumulating in the office of an Engineer, it is to be wished that more of these data were placed at the public disposal, for it is on such alone that any true theories can be constructed."

The work here referred to was soon out of print. During the long interval which has elapsed it would have been easy to reprint, but the author was anxious to improve the work, and extend matter which was compiled originally rather in the form of notes than as an exact treatise, and with considerable hesitation whether such dry figures would secure a reader. The practice of Engineering has now become so wide, that the projection and advising in London on works situated in every part of the globe is a matter of daily occurrence; it has, therefore, been apparent during the eleven years occupied more or less in collecting the data for this work, that it would be impossible to take too wide a range for the information to be contained in a Manual of Hydrology.

Thirty years since, the young Engineer requiring information and experience was compelled to search desultory reports, or the few works and essays published by mathematical professors; but, with rare exceptions, hydrodynamics formed the only subject then treated as part of the science of engineering. The refined but practical questions of surface slope and velocity of water, and, above all, of the volume accompanying given fall and velocity, or certain known rainfall, were subjects almost untouched; the source or supply of water

in reference to the amount of rain was a subject which only a few canal and water-works engineers had investigated; and they were not much disposed in olden times to communicate the practical experience acquired by the hard labour of years.

Hydrological science embraces the widest conditions: not only has the climate to be considered, but the elevation, inclination, and geological formation of the sub-stratum. Practical construction requires great previous experience, when the science has to be applied; for instance, in drainage and waterworks the theoretical size of pipes and drains is not always sufficient, owing to the margin required for deterioration or foreign deposits; and, above all, the question of velocity is one contingent on the materials of the sides and on the slope, within the limits of the outlay applicable to the given locality and requirement.

This work may probably fall into the hands of the younger members of the profession; the author would therefore venture to impress a few considerations upon those who have the future before them. No one can be competent to advise upon the legal questions arising out of floods—alterations of water courses and weirs—or the critical refinements which occur in cases of contiguous millowners—the service of water where more than one party is interested—the consequential effect of new works, either speculative, as when before Parliament, or alleged, when works have been carried out—unless he be thoroughly conversant with theory and practice; that is, unless there be a knowledge of results in previous cases.

The treatise being designed strictly to form a practical manual for every-day use, it would be out of place to have entered at any length upon theory: fortunately, at the present time this is not absolutely required, as of late years several valuable treatises have been published in our own language. Without wishing to particularize any one work as better than another, when all are excellent, mention may be made of Bennett's translation of D'Aubuisson's Treatise; of Dwyer's Practical Hydraulics (Dublin); and of the com-

pendious "Manual of Hydraulics," by Professor Dowling, of Trinity College, Dublin. "Hydraulic Formulæ," by Mr. John Neville, C.E., gives very clearly the leading mathematical principles of Hydraulics, with the gist of Du Buât's Treatise.

Having now written his apology, the author has to state that the calculations have been generally made and superintended by Mr. R. C. Despard, C.E., to whom the design is due of several of the valuable tables in the first division. Mr. Septimus Beardmore, C.E., undertook the collation and revision of a considerable portion of the tables in the fourth division; this, and other parts of the work, could not have been carried to so great an extent if it had not been for the indefatigable researches of Mr. H. S. Eaton, M.A., to whom the author is indebted for great assistance. It is superfluous to mention that the writings, personal communications and labours of James Glaisher, F.R.S., the pioneer of systematic meteorological observations in this country, have formed the basis of the tables in Division IV. Messrs. G. K. Olliver, C.E., and R. Twigg, C.E., have given their careful assistance to the tables and explanatory drawings.

It must be well known that the author's time is entirely occupied by practical avocations: although this has very much increased the personal labour of a kind of work that suffers so much from interruption, he has nevertheless felt pleasure in endeavouring, with the kind assistance already referred to, to lay before the profession a handbook on a group of subjects not hitherto collected into one treatise.

In compiling this work the following authorities have been consulted; many of them are professional friends, whose private communications, manuscripts, notes and collections of facts have been freely placed at the author's disposal; these resources would have been more extensively used, if time, and the reasonable limit of a volume of figures, had permitted. The various authorities have been named in the body of the

work, when quoted; if there has been any omission in this respect, it has been from inadvertence.

Alas! The hand of death will remind many what havoc the overworking spirit of the age has made in our ranks.

Westminster, March 19, 1862.

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The Astronomer-Royal; J. F. Bateman, C.E.; J. W. Bazalgette, C.E.; G. P. Bidder, C.E.; George Burnell, C.E.; John Coode, C.E.; A. Duncan, C.E.; Adm. Evans, R.N.; Admiral Fitzroy, R.N.; R. B. Grantham, C.E.; Thomas Hawksley, C.E.; J. B. Hartley, C.E.; W. Haywood, C.E.; the late Manuel Johnson, Oxford; James Leslie, C.E.; Elia Lombardini, of Milan, C.E.; G. F. Lyster, C.E.; R. W. Mylne, C.E.; I. Page, C.E.; W. Pole, C.E.; George Rennie, C.E.; Secchi, Rome; James Simpson, C.E.; A. D. and T. Stevenson, C.E; John Taylor, C.E; The Master of Trinity, Cambridge; Messrs. Walker, Burges and Cooper, C.E.; Captain Washington, R.N. The observations of members of the British Meteorological Society.

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DIVISION I.—HYDRAULIC AND OTHER TABLES.

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Every endeavour has been made in this work to adhere to uniform measures; except when specially stated otherwise, it must be understood that:—

All quantities of water in this work are given in cubic feet per minute.

Velocities	,,	,,	in lineal feet ,,
Measures	,,	,,	in feet.
Fall or surface slope of water		,,	in inches per mile.
Rainfall and evaporation		,,	in inches in depth.

All foreign measures have been converted into English, in expressing formulæ and in the reproduction or compilation of tables from the works of continental authorities.

Fractions, or parts, are expressed in decimals.

Volume or Flow of water (discharge) is generally referred to as the uniform quantity of cubic feet which would run off per minute for each square mile; this quantity is also expressed by the equivalent depth *in inches* spread over the whole area, provided such were discharged in a given time; thus 53 cubic feet per minute per square mile flowing uniformly for one year is equivalent to 12 inches in depth run off in the same period. See tables at pages 60-61.

The summations and means of rainfall and other tables herein given are not always the precise results of the figures in the tables, owing to the second place of decimals being frequently omitted for the sake of conciseness.

Tables for changing foreign measures into English, with other useful conversions, will be found between pages 62 and 70.

DIVISION I.

HYDRAULIC AND OTHER TABLES:

REMARKS ON THEIR USE.

DISCHARGE OF SLUICES, RESERVOIRS, &c.—Table 1.

THIS Table is computed on the law that the velocity of a body, falling from a height, expressed in feet per second, is as 8.04 times the square root of the height. When water falls freely under highly favourable circumstances, its velocity is nearly this theoretic quantity, and is represented in column B, in feet per minute, opposite various heights shewn in column A.

The column C is calculated from a co-efficient $7.5\sqrt{h}$, and should be used for finding the effective velocity of water passing through orifices of the form of the *venâ contractâ*, through well-constructed bridges, and ordinary sluices with good side walls; very large and well-placed sluices; and through wide openings whose bottom is level with that of the reservoir. This table also gives the discharge through well-placed and large vertical pipes, and narrow bridge openings, by deducting 1-9th from the tabular velocities.

The column D is calculated from a co-efficient of $5\sqrt{h}$, and should be used for the effective velocity of water through sluices without side-walls, such as are used commonly upon mill-streams and rivers, undershot wheel gates and canal lock or dock-gate sluices. When these are constructed in a very suitable form, an intermediate between columns C and D is sometimes available.

RULES AND EXAMPLES FOR THE TABLE.

First.—When the area of the orifice and the head of water are given, to find the discharge in cubic feet per minute; *Multiply the number in the table of the column* C *or* D, *according to the case, by the area of the orifice expressed in feet and decimals.*

Examples.—The fall of water is .05 through a bridge which has 500 feet of sectional area; what is the discharge?

Tabular number of column C, opposite .05, is 100.3 × 500 = 50,150 cubic feet per minute.

The difference of level between the upper and lower ponds of a canal is 6 feet; what is the discharge with a sluice having 4 feet superficial area of opening?

The total height being 6 feet, and opposite 6.00 in column D, is 734.7 × 4 = 2,938, which divided by 2 for the mean discharge due to the height, gives 1,469 cubic feet per minute. If the lock be 100 feet long and 18 feet wide, it will hold 10,800 cubic feet of water, and consequently take 7.34 minutes to fill; this would be too long, therefore the lock should have two sluices, each of 4 feet area.

Second.—When the discharge and the area of the opening are given, to find the head required; *divide the given discharge in feet per minute* (*adding* 1-8*th for pipes*) *by the area of the orifice in feet, find the result in column* C *or* D, *according to the case, and column* A *will show the head required.*

Third.—When the discharge and the head of water are given, to find the area of opening; *divide the given discharge* (*or half such with a head decreasing* to zero*) *by the tabular discharge opposite the given head* (*deducting* 1-9*th of column* C *for pipes*) *and the result will be the area of the orifice required.*

Examples may be worked from the former ones, thus:—Required the area of lock sluices to run 2,938 cubic feet per minute, with six feet difference of level; or in other words, to empty a lock 100 feet long and 18 feet wide, in 3.67 minutes.

The tabular number for 6 feet of head, in column D is 734.7, and the mean discharge for the gradually decreasing head of the emptying lock, will be half, or 367.3 cubic feet per minute; then $\frac{2938}{367.3} = 8$ feet area of sluice required.

A vertical pipe is required to discharge 138 cubic feet per minute from a reservoir with 50 feet head; required the area and consequent diameter?

The tabular number opposite 50 feet of head is 3181.95, which reduced 1-9th is 2828.4. Then $\frac{138}{2828} = .049$ for the area of the pipe, which by the table of areas will be found to be four inches diameter.

---

* Where the orifice of the sluice is covered, as in locks and river sluices, the "head of water" is the difference of level between the respective surfaces; in other cases, the head is to be taken from the surface to the centre of the opening: and for bridges, or similar cases, the accurate difference of level between the water surface on the upper and lower side of the bridge. When water is drawn down, as out of a lock with a head gradually diminishing to nothing, the discharge will be as the maximum head in half the time; or in other words, for a head of six feet gradually diminishing to nothing, the main discharge will be half the tabular number (for six feet) per minute for the whole time. Other cases of reservoirs, &c., emptying or filling with an increasing or decreasing head, require intricate calculation.

GENERAL RULES FOR DISCHARGE FROM SLUICES, TANKS, RESERVOIRS, AND VERTICAL PIPES.

First Case.—Multiply the square root of the given head in feet, by 450 (400 or 300) times the given area in feet; the result is the *discharge in cubic feet per minute.*

Second Case.—Divide the discharge in cubic feet per minute by 450 (400 or 300) times the area in feet; the square of the result is *the head in feet.*

Third Case.—Divide the discharge in cubic feet per minute by the product of 450 (400 or 300), multiplied by the square root of the given head in feet; the result is *the area of the pipe or opening.*

Note.—450 is the multiplier for bridges, &c.

400 ,, pipes, &c.

300 ,, ordinary sluices, &c.

The Rules and Tables above described, when carefully applied, will be found to meet all ordinary cases in practice. The observer will frequently find his sluices, &c., more or less favourably circumstanced, and he must exercise his discretion accordingly. Where there are very severe bends in pipes and culverts a loss of discharge is occasioned, which is treated of in another place.

DISCHARGE OF WEIRS OR OVERFALLS.

Tables 2 and 2a.

Table 2 is computed by the formula $D = 214 \sqrt{H^3}$, where D is the discharge in cubic feet per minute, for one foot in width of the waste-board or sill of the weir, and H is the true height from the top edge of such sill to the surface of water where it is at rest, or nearly so. The principle of the formula is, that the curve of the water falling over is a parabola; consequently there can be discharged only two-thirds of the water which would pass the full section due to H; the constant 214 is two-thirds of 321, which has been found, by frequent trials, to represent the factor, to be multiplied by $\sqrt{H}$ for giving the mean velocity in feet per minute of water passing over an obstacle such as a waste-board. The constant 214 is consequently liable to some variation under favourable circumstances; for instance, where the weir is formed of a number of short bays, divided by beams. In these cases, the water passing the

edges assumes the *vend contractâ* form, and consequently the width of the opening should be reduced for the true quantity of water passing. These and other causes which may render the observation liable to error, must be treated with judgment, according to circumstances.

Table 2a.—When fromany cause, such as the comparative smallness or rapid declivity of the channel above the weir, the water arrives with an appreciable velocity at the point where the still head begins to deflect, the discharge calculated by Table 2 would be below the truth. **Table 2a** has, therefore, been calculated in order that the true discharge may be obtained. The formula used is $D = 214 \sqrt{H^3 + .035 v^2 H^2}$, in which v = velocity of approach or *initial velocity* in feet per second, This formula is obtained by adding to the measured head H, a height h, sufficient to generate the initial velocity, and calculating the velocity over the weir from the total head so obtained (H + h). As h is an unknown quantity, its equivalent in terms of the velocity is added to H, in the formula above given. In a work of this nature it is, of course, impossible to enter at length into theory, those who wish to obtain fuller information on this and other hydraulic subjects, will find it in Professor Downing's valuable treatise referred to in the preface, and other well-known works, such as those of D'Aubuisson, Du Buat, etc.

PRACTICAL APPLICATION FOR GAUGING.

The best way of gauging weirs is to have a post with a smooth head level with the edge of the waste-board or sill; *to be driven firmly* in some part of the pond above the weir which has still water. A common rule can then be used for ascertaining the depth, or a gauge, to shew at sight the depth of water passing over, may be nailed on, with its zero at the level of the sill of the weir. The depths in the table are given in feet and decimals, as used in ordinary levelling: this unit abridges calculation, and is altogether better than measurement by inches, which has been the more usual custom. Among practical engineers, gauging by a weir has been always justly held to afford the most certain and efficient result, and especially for ascertaining the *comparative discharges* of streams, which, in cases of litigation and arbitrations, is often as important as ascertaining the *real quantity*. The plain rules for correct gauging and use of Table 2 should be, absence of wind and current, a good thin-edged waste-board, and a weir not so long in proportion to the width above it as to wire-draw the stream; in the latter case, the water will arrive at the weir with an initial velocity due to a fall which is not estimated for; in this case Table 2*a* must be used. The best method of ascertaining the initial velocity is by a float, passing over a space of 100 feet, or thereabouts, before arriving at the weir; the surface velocity will thus be obtained. That given in the formula is the mean, but for all practical purposes these two velocities may be considered as equal. A weir, for correct gauging, should always have a free fall over; but there are sometimes cases where measurements are required with drowned weirs—so called when the tail water has risen above the level of the sill. In this case we have two conditions to deal with; first, the water passing at a depth represented by the difference of levels of the upper and lower may be treated by this Table as a simple overfall; secondly, there is a section of water passing between the top of

the waste-board and level of the lower water, whose mean velocity will be that due to the difference of level or head above mentioned. The velocity and discharge of this portion of the weir can then be computed by taking the mean of columns C and D, Table 1: the sum of the two will give very nearly the true discharge.

The application of the Table in constructing weirs for relief of flooded lands is obvious.

A paper was read before the Institution of Civil Engineers in 1851, by T. E. Blackwell, Esq., then Engineer of the Kennet and Avon Canal: it is published in their *Minutes*, and will be found well worth study, as containing a condensed account of a vast number of experiments which must have taken great time and labour. The result of Mr. Blackwell's experiments seems to be, that under favourable circumstances, the constant by which the Table No. 2 is calculated, is substantially correct; that is to say, in a good situation for the flow of water approaching, and with a thin waste-board. With thick waste-boards, and narrow openings, the results are generally .80 of those which would be given by the Table.

One important and useful set of his experiments, is on weirs with a lip three feet wide, having its edge level, or with a small slope in the transverse section; this is a case frequently met with in practice, and we find that the results of Mr. Blackwell's experiments give from .70 to .75 of the Tables, which is quite consistent with the allowance we have generally found it necessary to make, where so much friction is involved.

SURFACE, MEAN, AND BOTTOM VELOCITIES Of Rivers, Streams, and Estuaries.—Table 3.

This Table is computed from the formula $b = (\sqrt{s}-1)^2$, where the velocity at the surface in the middle of a river is s, and that at the bottom b. The column of mean velocities is $\frac{s+b}{2}$; or it may be found in an easier way by taking the mean velocity, $m = s - \sqrt{s} + .5$. In Du Buât's formula, the velocities are expressed in inches per second, but in the Table they are reduced to feet per minute, which is made the unit throughout this work, where applicable.

The bottom velocity obtained from $(\sqrt{s}-1)^2$, is that prevailing directly beneath the point at which the corresponding surface velocity has been observed; therefore, in order to obtain a true mean, the *mean surface* velocity should first be obtained either of each special portion of the section of a river or of its whole section, as the case may be. *The mean velocity of a stream is fairly represented by the maximum velocity* × .8, as a rough rule.

The Table shews, by inspection, the relative velocities of streams of all kinds, extending from 5 to 950 feet per minute. Its most important use is for gauging the quantity of water passing down any river or stream. For this purpose, get the surface velocity at the various parts of the stream, by observing, either with a current meter, or with floats barely reaching the surface, and offering no space to the action of the wind; their velocity being noted by fixed buoys or by marks upon shore. The mean velocity

corresponding to that of the surface as then obtained, is, in fact, an imaginary quantity, representing the mean of the vertical section of water passing the place of observation; therefore, when the discharge of a stream is required, take cross sections where the channel is straight, and divide into portions of uniform depths, and observe the velocity of the surface of each portion; the corresponding mean velocity multiplied by the area of each portion of the section will give the discharge. If a current meter is used, take the velocity at the place of section; or if floats, take their time of passing between two sections; in either case repeating the observations at several places, for obtaining an average, and using the greatest judgment in selection of places for trial, for otherwise the whole is liable to be incorrect.

The bottom velocities are chiefly useful for shewing the permanent limit of the bank, &c., of a stream which may be required to be straightened or made *de novo*. If any river pass at a greater rate than the banks will bear, it is a beautiful law of nature, and most certain in its effects, that a greater sectional area is cut out; and thus the hydraulic mean depth being increased, the surface slope becomes flatter, and the general velocity and scouring action is reduced. It is most essential to the success of artificial cuts that their bottom velocities should not exceed the permanent limit of the material through which they pass. The first action of this kind destroys the whole economy of a work,—deepening unequally is commenced,—eddies and shoals must follow, and inequality of water surface accompanies the evil, reproducing these effects.

The second page of this Table is headed by a statement of the effect of bottom velocities on materials through which rivers are usually cut, and they form a criterion for the limiting bottom velocities of new cuts. It will be found, however, that this statement somewhat overrates the effect produced by currents when applied to rivers as they exist, especially where there is admixture of clays, the resisting power of some kinds of which material is very high. There are constant occurrences of higher velocities than those quoted, which offer no permanent damage to the bed of rivers; in point of fact, the bottom very frequently becomes covered with weed or slime, which much prevents the effect of abrasion. There are, nevertheless, many rivers flowing in channels cut out of their own alluvium, such as in the Delta of the Nile and Ganges, where alteration of channel is perpetual.

The most recent and complete experiments on the practical effect of running water, are those made by Mr. T. E. Blackwell, C.E., for the Government Referees on the Metropolitan Drainage Plans, with the object of ascertaining what velocities are applicable to the movement of materials liable to be collected in sewers. But the facts are capable of much further extension; for although the abstract power of running water to remove a given mass is a mere question of calculation, yet there are questions of friction and adhesion of substances to each other, that can only be solved by practical experience.

The table on the opposite page gives the results of these experiments; they were made in a rough elm trough, 60 feet long, 4 feet wide, and 3 feet deep, set horizontally, and fed by a pond at 2 feet higher level, with sluices so placed as to direct a current uniformly down the trough, on the bottom of which the materials experimented upon were laid. The table is used thus: the strong figures at top represent the velocities given to the current; the smaller figures opposite each class of material shew the velocity at which they were moved with the current stated at top of each column; thus, broken granite No. 1, started with a velocity of current between 2.00 and 2.25 feet per second, and moved at the rate of 1.00 foot per second, with a velocity of between 2.75 and 3.00 feet per second, and so on.

TABLE SHEWING THE EFFECT OF RUNNING WATER IN MOVING VARIOUS SUBSTANCES,

From Experiments made by T. E. BLACKWELL, ESQ., C.E., *in* 1857.

Description of Substance.	Weight.	Cubic Contents.	Specific Gravity.	Velocities at which substances, moved in Feet per Second.	Velocity of Current in Feet, per Second.														
					1.00 to 1.25	1.25 to 1.50	1.50 to 1.75	1.75 to 2.00	2.00 to 2.25	2.25 to 2.50	2.50 to 2.75	2.75 to 3.00	3.00 to 3.25	3.25 to 3.50	3.50 to 3.75	3.75 to 4.00	4.00 to 4.25	4.25 to 4.50	4.50 to 4.75	4.75 to 5.00
	oz.	c. in.																	
Brickbat	22. 0	18. 5	2.05		...	...	...	...	...	...	...	start	0.94	1.15	1.25	1.30	...	2.14	2.31	...
,,	16. 0	13. 6	2.03		...	...	...	...	start	...	...	1.15	...	...	1.50	...	...	...	2.31	...
,,	9. 0	7.33	2.12		...	...	...	...	start	0. 7	0.82	..	1.20	...	...	...	1.87	2.00	2.61	...
,,	6. 0	4.76	2.18		...	...	...	...	...	start	...	...	0.42	...	1. 2	...	2.00	2.14	...	...
,,	3. 0	2.59	2.00		...	...	...	start	...	...	1.00	...	...	1.50	...	...	...	...	...	...
Building Stone	22. 0	17.68	2.15		...	...	...	..	...	...	...	start	1.00	1.15	1.25	1.43	...	...	...	...
(Oolite)	9. 0	6.70	2.32		...	...	...	...	...	...	start	0.91	...	1.15	1.20	1.25	1.87	...	...	...
,,	3. 0	2.39	2.17		...	...	...	...	start	...	...	...	...	1.36	1.43	1.87	...	...	2.22	...
Chalk	22. 0	18.54	2.05		...	...	...	start	...	0.60	0.67	...	1.20	1.30	...	1.67	...	1.76	...	...
,,	16. 0	12.74	2.17		...	...	...	...	...	start	...	1.00	1.11	1.50	...	1.87	...	...	...	...
,,	9. 0	7.78	2.00		...	...	...	...	start	...	0.93	...	1.36	...	1.87	...	...	...	...	...
,,	6. 0	5.18	2.00		...	...	...	...	start	...	0.92	...	1.15	1.58	...	1.67	2.14	...	...	...
,,	3. 0	2.39	2.17		...	...	...	...	...	start	0.75	0.94	1.03	...	1.77	...	...	...	...	...
Flints	16. 0	10.37	2.67		...	...	...	...	...	...	...	...	start	...	1.00	1.06	...	1.56	1.84	...
,,	9. 0	6.05	2.57		...	...	...	...	start	0.70	...	...	...	1.30	1.50	...	...	...	...	...
,,	3. 0	1.95	2.66		...	...	...	...	...	...	start	...	...	1.07	1.36	1.43	1.76	...	...	...
Coal	22. 0	28.59	1.33		...	...	start	...	...	...	0.91	...	...	1.50	1.76	1.87	...	...	...	...
,,	3. 0	4.11	1.26		...	start	0.45	...	...	1.11	...	...	1.87	2.00	...	...	...	...	...	...
Limestone	5. 0	3.02	2.86		...	...	...	...	...	start	...	...	...	0.94	1.11	...	1.58	1.67	...	...
,,	3. 0	1.73	3.00		...	...	...	...	...	...	start	...	...	0.90	...	...	1.25	...	1.43	2.00
,,	1. 5	0.86	3.00		...	...	...	...	...	...	start	...	...	...	...	1.00	...	1.25	...	...
Slates	15. 0	9.06	2.86		...	...	...	...	...	...	...	start	...	...	...	2.00	...	...	2.14	...
,,	4. 0	2.38	2.90		...	...	...	...	start	...	...	0.68	...	...	...	...	1.43	2.00	...	...
Granite (broken)	6. 50	4.22	2.66		...	...	...	...	start	...	0.65	1.00	...	1.15	1.25	...	1.76	...	...	...
,,	3. 0	1.94	2.67		...	...	...	...	start	...	...	...	...	...	...	1.00	1.44	...	1.87	...
,,	1. 50	0.97	2.66		...	...	...	...	...	...	...	start	...	1.11	...	1.30	1.50	2.00	...	...
Boulders	11.87	...	...		...	...	...	start	...	1.08	...	1.30	...	...	...	...	1.53	...	...	...
,,	5.87	...	...		...	...	...	...	...	start	1.11	...	...	1.67	...	...	2.14	...	...	...
,,	3.31	...	...		...	...	...	...	...	...	start	...	1.50	...	2.00	...	2.31	...	...	...
Gravel, $\frac{1}{2}$ inch	...	...	1.41		...	start	...	...	...	...	...	...	...	...	...	...	...	...	...	...
,, $\frac{1}{8}$ inch	...	...	1.46		...	...	...	...	...	start	...	...	...	...	...	...	...	...	...	...

The most useful instrument for getting velocities, where a float is not applicable, and where an under current is probable, is the current meter, formed by a vane in the Archimedean form, carrying an endless screw, which turns a wheel divided on the circumference. This very convenient instrument should be made with a second or differential wheel, worked by the same screw, having one tooth less than the first, and shewing in its revolution about 1,128 turns of the first wheel; this gives the power of leaving the instrument under water for a considerable time, which is frequently very desirable for obtaining a good mean velocity. In gauging by velocities, care should be taken to ascertain that the current does not under-run at the place of observation. This phenomenon frequently occurs in rivers and tidal streams, where the passage is narrow and deep, the latter generally an effect of the under-current rather than a cause. At sharp bends of large rivers, and at headlands on sea-coasts, it generally occurs, and is detected on the surface by the races which are formed. Striking instances may be seen off the Isle of Portland, and some of the bold headlands of Cornwall, Wales, and the north and west of Ireland and Scotland.

ARTERIAL DRAINS, RIVERS, &c.—Tables 4 and 4a.

The rule on which these tables are constructed is—multiply the hydraulic mean depth in feet by twice the fall in feet per mile; take the square root of the product and multiply it by 55; the result is the mean velocity of the stream in feet per minute; this again multiplied by the sectional area in square feet, gives the discharge in cubic feet per minute. The hydraulic mean depth is obtained by dividing the sectional area of the stream by the border or wetted perimeter: in pipes this is simply one-fourth of the diameter. The table is arranged for falls of 2, 3, 4, 5, 6, and 9 inches per mile, but, by referring to the rule at the head of the table, it can be readily extended to 12 more rates of fall per mile—and even further extended by using the following rule, viz.: the velocity and discharge varying as the square root of the fall, *half the discharge or velocity of any given fall* will be the discharge or velocity for *one-fourth that fall*; or vice versâ, *for the discharge or velocity of four times any given fall per mile*, take twice the discharge or velocity of such fall.

Table 4a is given chiefly for application to large rivers, and it will be found to include in its dimensions some of the greatest examples. As applied to tidal rivers it shews that enormous power of discharge is given to large sectional areas, however small the fall, simply because the tabular results are based upon *uniform construction and regular beds*. Having analysed numerous actual observations of rivers, the author has never found the rule for this table at fault, when the conditions were fairly represented in the experiments.

The application of these tables to cuts of all kinds for straightening rivers, for forming mill heads and carrying off flood waters, is sufficiently obvious. The tables shew the slopes that rivers of various sizes will assume under the laws of gravity influenced by friction of the bed; giving by mere inspection what would otherwise require tedious computation.

CIRCULAR AND EGG-SHAPED CULVERTS.
Tables 4b and 4c.

Table 4b gives the discharge and velocity for culverts from 8 feet to 1 foot in diameter, as if half full and three-fourths full; shewing also the area of water-way at such depths respectively. The data given are with inclinations from 2 to 7 feet per mile, which will embrace the usual practical range. It is computed by the formula as described for Table 4, but it does not differ materially from the results obtained from Table 8, although the method of computation is totally different.

Table 4c gives the same information in every respect as Table 4*b*, for oval culverts; the vertical and transverse dimensions are given in the first column; in Table 4*b* will be found circular culverts of the same sectional areas while half full and three-fourths full, so that a comparison is afforded of the discharge of the circular and oval form.

Great care should be taken in adapting the size of any culvert to the fall and duty expected. If too great a velocity be given, the water is apt to flush onwards, so as to require control, and, as it were, to force it to follow the slope of a channel which is not adapted to the case.

ARTERIAL DRAINS.—Table 5,

Is a universal table for obtaining velocities of new cuts, rivers, &c., calculated from the formula given in Leslie's "Natural Philosophy," Art. Hydrodynamics, viz., $\frac{6000\sqrt{HD}}{\sqrt{\frac{l}{h}}}$ = mean velocity in feet per minute, in which HD is the hydraulic mean depth, obtained by dividing the sectional area by the wetted perimeter, both in feet.

This formula is a modification of that applied to pipes in Table 8. The formula used for Tables 4, 4*a*, *b*, *c*, given on page 11 when reduced to similar terms, becomes $\frac{5652\sqrt{HD}}{\sqrt{\frac{l}{h}}}$ = velocity in feet per minute, and gives results 5.8 per cent. lower. Table 5 is applicable only to channels constructed with great care, and straight in direction, or nearly so; allowance must, therefore, be made by the engineer for bends, irregularities of bed, &c. &c. Tables 4, 4*a*, *b*, *c* will be found to afford more correct results for arterial drains, &c., as ordinarily constructed.

In a paper "On the flow of water through pipes, &c.," by Mr. Leslie, of Edinburgh, read before the Institution of Civil Engineers in 1855, an account is given of experiments made on the flow of water in the conduit of the Dundee Water Works. This conduit is 2 feet wide, with vertical sides, and a bottom of smooth stone slabs. In the first set of experiments the gradient was 1 in 1000, and the depth varied from 6 inches to 1 foot. The difference between the discharge as actually measured, and as calculated by the formula used for this table, did not exceed 1 per cent. In a second set of experiments on the same conduit the gradient was 1 in 365, depths 4§ to 7 inches; the measured discharge varied from 3.2 per cent. below, to 2.4 per cent. above, the results given by the formula. In the conduit of the Edinburgh Water Works, of similar dimensions, but built of brick and frequently obstructed by deposits of sand, the results were in general 10 per cent. below those of the formula.

CIRCULAR PIPES.—Table 6

Contains areas, circumferences, and square roots of 5th powers, in feet, for diameters, varying from ¼ inch to 12 feet, calculated expressly for this work. It will be found of great use in working out discharges, &c., by the hydraulic and other formulæ of various authors; for example, those for Tables 7 and 8 below.

GAS PIPES UNDER PRESSURE.—Table 7

Is a universal Table, calculated from the formula.

$$Q = \frac{19400\sqrt{d^5}}{\sqrt{s\frac{l}{h}}}$$ in which

Q = discharge in cubic feet per minute.
d = diameter in feet.
l = length in feet.
h = head or pressure in inches of water.
s = specific gravity of gas. Air = 1.00.

This formula is reduced from that given by Mr. Pole in his paper on the "Motion of Gaseous Fluids in Pipes," published in Clegg on the "Manufacture of Coal Gas." The table is applicable for air or any kind of gaseous fluid by using the proper specific gravity. The mode of using it is explained in the heading.

WATER PIPES UNDER PRESSURE.—Table 8

Is a universal table* for the discharge of water pipes and culverts from one inch to ten feet in diameter; its mode of use is explained in the table; the constants merely require to be divided by the square root of the rate of fall to give the discharge in cubic feet per minute.

The formula used is deduced from that known as Eytelwein's, viz.,

$$\frac{2356\sqrt{d^5}}{\sqrt{\frac{l}{h}}} = \text{discharge in cubic feet per minute,}$$

in which d = diameter of pipe in feet; l = length in feet; h = head in feet; and 2356 is a number obtained by multiplying the constant 50 for velocity in feet per second (derived from experiments), by 60 or minutes and by .7854 or area of circle. The original formula gives, as a divisor, $\sqrt{\frac{l+50\,d}{h}}$ but for pipes of any considerable length, the term $50\,d$ (which is added to allow for the flow of water coming into "train") may be disregarded.

If the velocity in feet per minute is required for a given fall and diameter of pipe, divide the discharge (as found by the table) by the area of the pipe, expressed in square feet.

* The design of this table is due to Mr. James Leslie, C.E., Edinburgh, who has kindly permitted its use. The table is entitled "Pipes Under Pressure," as particularly adapted for such use: but it is also applicable to culverts, &c., of course apportioning the amount filled, whether half or three-fourths, and having due reference to the slope not creating too high a velocity and over gorging.

If the head is required for a given discharge, length, and diameter of pipe, divide the tabular number of the diameter by the discharge, and square the quotient; then divide the length by this number, and the result will be the head in feet.

EXAMPLE.—A pipe 2 feet in diameter and 5,000 feet in length, is required to carry 300 cubic feet per minute, what should be the head?

Tabular number for 2 feet pipe $= \frac{13,327}{300} = 44.4$; then $44.4^2 = 1,971.3$ and $\frac{5000}{1971.3} = 2.54$ feet, *which is the head required.*

If the diameter of pipe is required for a given head, length, and discharge, then $.235 \sqrt[5]{\frac{l \times q^2}{h}}$ = diameter in feet; l and h being as before, and q being the quantity discharged *in cubic feet per second.*

This last is a tedious formula, and the table gives the same result for a vast range of discharges, by following the second rule thereon.

Where culverts are not circular, take the diameter corresponding to a circle of the same sectional area, and the result will be *very nearly correct.*

WATER PIPES UNDER PRESSURE.—Tables 8a and 8b.

Table 8a gives the discharge and velocity for pipes from 3 to 60 inches in diameter, at rates of fall from 5 to 35 feet per mile. **Table 8b** gives the discharge and required head for pipes running full at stated velocities.

These tables are computed from Table 8, and will be found useful for ready inspection, the knowledge of comparative results being highly desirable when designing works or computing their probable effect.

In using these tables we must repeat a caution given elsewhere, that a due feed into a train of pipes, absence of inequality in slopes, of sudden bends, &c., are highly necessary to obtain a proper discharge.

For pipes under pressure, 200 feet per minute is a very good working velocity, giving probably better proportional discharge than greater fall and consequent speed is likely to do; a velocity of 150 per minute will generally prevent deposit in pipes and sewers. In designing hydraulic works the engineer should carefully consider the velocity proposed to be given, having reference to the rapid increase of resistance (viz., as velocity^2) to the flow of water at high speeds.

Under proper conditions of inlet, outlet, straightness of track, &c. &c., the foregoing Tables 8, 8*a* and 8*b* give sufficiently accurate results for pipes from 3 inches to 4 feet in diameter, at medium rates of inclination. This will be seen upon reference to Mr. Leslie's paper "On the flow of water through pipes," &c, before referred to, and the discussion which ensued thereupon. For very small pipes or flat rates of inclination, or waere a closer approximation to accuracy may be desired, somewhat better results may be obtained by using Du Buât's formula, viz.:—

$$\frac{307\ (\sqrt{r} - 0.1)}{\sqrt{\frac{l}{h}} - L\left(\sqrt{\frac{l}{h}} + 1.6\right)} - 0.3\ (\sqrt{r} - 0.1) = \text{Velocity in inches per second.}$$

$r = \frac{\text{dia}}{4}$ = "Mean radius" or Hydraulic mean depth in inches.

L = Hyperbolic Log. of the term to which it is prefixed.

Hyperbolic Log. = Common Log. × 2.30258. When reduced

to terms of the diameter in feet, and to give the discharge in cubic feet per minute, this formula becomes :—

$$\frac{2088.1\,(\sqrt{d^5} - .0577d^2)}{\sqrt{\frac{i}{h}} - L\,(\sqrt{\frac{i}{h}} + 1.6)} - 2.04\,(\sqrt{d^5} - .0577d^2) = \text{Discharge in}$$

cubic feet per minute.

In applying this formula, it must be observed, that in the rate of inclination or $\frac{i}{h}$, h is the head or height required to overcome friction and other resistances. It is therefore necessary after obtaining the approximate velocity by the formula to deduct from the total height (H), the head (h^1) required to produce this velocity, and to use the new head ($H-h^1=h$) as the denominator of the fraction $\frac{i}{h}$ in recalculating the velocity; this operation being tentative should be repeated as often as may be considered desirable. To find h^1, look in Table 1, Col. B, for the nearest velocity, and opposite to it in Col. A will be found the height. Table 6 will save much time in giving by inspection areas and $\sqrt{d^5}$, but notwithstanding these or any other tables which can be devised, computation by this formula is necessarily tedious, and the ultimate results do not materially differ from those obtained by using Table 8.

The principles on which the formula of Du Buât is based are summed up by him as follows (Principes d'Hydraulique, vol. I. which should be consulted by those who require fuller information) :—

"1. The molecules of water may be regarded as bodies of inconceivable tenuity, perfectly hard and polished. In such a system of corpuscules pressure can have no influence on friction.

"2. Rivers cannot flow without a surface inclination, and the force resulting from this is the sole cause of their movement.

"3. When the mean velocity of a current is uniform, the accelerating force is in equilibrium with the resistance of the wetted border. Tubes or pipes in this respect are like rivers, provided there be deducted from the entire height (H) of the reservoirs the head (h^1) required to generate the velocity, and that the remainder ($H-h^1=h$) be considered as giving a declivity to the whole length of the pipe. Thus the absolute weight of the column employed to overcome resistance is equal to that of the column of the same diameter which is moved, multiplied by $\frac{h}{l}$; the rate of inclination being expressed fractionally so as to make h=1.

"4. The molecules of water introduce themselves into the pores of the perimeter, filling all the little unevennesses of the surface. Thus they themselves form the surface upon which the whole volume flows, whence it follows that the different materials of which the perimeter may be composed do not sensibly affect the intensity of the resistance.

"5. The surface of the wetted perimeter may be regarded as an assemblage of globules on which the moving particles flow; hence results a resistance proportional to the square of the velocity when the filling up of the molecular spaces (*engrenage*) is complete, viz., at low velocities; but, as this filling up diminishes in proportion as the velocity increases, so does the resulting resistance decrease, until it becomes nothing, when the velocity becomes infinite. From this principle, corrected by experiment, the relation between the velocity and the inclination in the same channel is expressed by $V=\frac{\sqrt{mg}}{\sqrt{\frac{i}{h}} - L\,(\sqrt{\frac{i}{h}} + 1.6)}$.

"6. The resistance to the molecules at the perimeter communicates itself to the whole mass, and the result for each molecule is in direct ratio to the perimeter and inverse to the sectional area; hence it follows

that at equal inclinations the velocities would be as the square roots of the area to the perimeter ($=\sqrt{\frac{a}{p}} = \sqrt{r}$ or mean radius) if this proportion were not altered by the attraction of the perimeters on the neighbouring molecules: this extends to the same distance in all channels, and experiment gives $\sqrt{m} = \sqrt{n}\ (\sqrt{r} - .1)$, and $\sqrt{ng} = 307$, for English inches.

" 7. As each molecule experiences a resistance in inverse proportion to its distance from the perimeter, it follows that the velocities of the various molecules vary according to these distances, and thus the molecules tend to separate continually; a part of the accelerating force is employed to overcome the reciprocal attraction of the molecules which opposes this separation. The resulting loss of velocity is equal according to experiment to 0.3 ($\sqrt{r} - 0.1$).

" 8. The velocity considered in the formula is the mean velocity of all the molecules."

The foregoing tables will meet cases of pipes and culverts, under simple conditions; but where bends (*see Friction of Bends*) and other complications are introduced, calculation becomes extremely intricate. The following experiments and facts from practice are inserted so as to throw light upon the loss of head in town supplies, and the effective value of pressure through long ranges of street main.

EXPERIMENTS ON THE HEIGHT AND DISCHARGE OF JETS, by the Southwark Water Company, January, 1844.

Pressure at Battersea 120 *feet, and every service pipe or other outlet kept shut. Stand Pipes* 2½ *inches diameter.*

First Experiment—in Union Street, between High Street and Gravel Lane, Borough, through stand pipes, hose, and jets; there being six stand pipes, each 360 feet apart, connected to a 7-inch main 2,400 ft. in length,

the head being carried on through a	9	,,	,,	1,500	,, ,,
,, ,,	12	,,	,,	600	,, ,,
,, ,,	15	,,	,,	1,650	,, ,,
,, ,,	20	,,	,,	10,350	,, ,,

Making a total distance of..... ..... 16,500 feet from the Head at Battersea.

Second Experiment—in Tooley Street, 9-inch main 4,200 ft. in length,

the head being carried on through a	15	,,	,,	3,000	,, ,,
,, ,,	20	,,	,,	12,750	,, ,,

Making a total distance of..... 19,950 feet from the Head at Battersea.

	Standpipes used.	Length of Hose.	Diameter of Jet.	Height of Jet.	Discharge per Minute.
	Number.	Feet.	Inches.	Feet.	Cubic Feet.
First Experiment.	1	40	7/8	50	15.7
	2	40	3/4	45	—
	3	40	5/8	40	—
	4	40	1/2	35	—
	5	40	3/8	30	—
	6	40	1/4	27	—
	1	80	7/8	—	16.6
	1	160	7/8	40	16.0
	1	40	2 1/2	—	42.1
Second Experiment.	*aa* 1	40	7/8	40	13.17
	aa 2	40	7/8	31	10.90
	bb 1	40	3/4	34	11.98
	bb 2	40	3/4	23	9.30
	1	40	1 1/4	60	17.15
	2	40	1 1/4	60	—
	4	40	1 1/4	45	14.90
	6	40	1 1/4	40	13.80

aa are through 600 feet of 5-inch main, but fitted on a 4-inch main close to the 5-inch main; *bb* are through 600 feet of 5-inch main and 600 feet of 4-inch main, both in addition to the 19,950 feet of main before described.

EXPERIMENTS ON THE HEIGHT AND DISCHARGE OF JETS, by the Preston Water Company, March, 1844.

From 6-*inch Main.* *Pressure* 110 *feet.*

	Height.	Discharge.		
With 1 jet...¾-in...	57 feet.....	12.5 cub. ft. per min.	by day.
,, 1 ,, ... ,,	64 ,, ...	14.4	,,	by night.
,, 2 jets ,,	56 ,, ...	12.5	,,	by day.
,, 2 ,, ,,	62 ,, ...	14.0	,,	by night.

From 6-*inch Main.* *Pressure* 46 *feet.*

	Height.	Discharge.		
With 1 jet...¾-in...	24 feet.....	4.8 cub. ft. per min.	by day.
,, 1 ,, ... ,,	...28 ,, ...	5.6	,,	by night.
,, 2 jets ,,	...20 ,, ...	4.5	,,	by day.
,, 2 ,, ... ,,	...25 ,, ...	4.8	,,	by night.

At Leeds, the author has seen jets thrown 60 to 70 feet high, and with great body and force, 40 to 50 feet high in the lower part of the town, where the pressure was 180 feet, and services in full draught.

At the West Middlesex Water Works, from experiments by W. T. Clarke, Esq., the friction of the pipes was found to reduce the head of water between one-fourth and one-fifth.

The Grand Junction Water Company's new engine at Kew, works against 205 feet of head, while the gauge on the other side of the stand, (indicating the back pressure from London,) gives only 170 feet; shewing a loss of 35 feet head, by the draft on the great 45-inch main.

At New York the height of the water is 115 feet above high water; 105 feet above the lowest, and sixty feet above the highest streets. The

distance from the distributing reservoir is 4 miles, by the direct 36-inch main. The city fountains throw from 60 to 70 feet high. At Haarlem River Valley, on the line of the aqueduct, a 12″ pipe and 6″ jet throws the water 110 feet high, with 189 feet pressure.

At Philadelphia the surface of water in the reservoirs is 98 feet above high water; 55 feet above the highest, and 93 feet above the lowest points in the city. The distance from the reservoir to extreme point of mains and pipes (which are always charged), is 6 miles, by a main from 20″ to 22″ diameter. The loss of head, by friction in the pipes, is about 25 feet while the city is drawing. The mains are from 10 to 12 inches in the principal streets, and from four to six inches in the minor ones.

The water will rise from a hose attached to a fire plug in the streets at the extreme point of delivery, during the night, to the height of about 45 or 50 feet; during the day, when the consumption of water is very great, the pressure is about 25 feet as above stated.

THE FOLLOWING TABLE is from experiments by Mariotte. The first and second columns give the relative height of jets and their head; the third column gives the discharge by an ajutage .53 inch diameter, and the fourth column contains the diameter which ought to be given to the service pipes for an ajutage of .53 inch, relatively to the altitudes in the second column. They are computed on the hypothesis that for an ajutage of .53 inch in diameter, and an altitude of 16 feet of water in the reservoir, the conduit pipes must be 2.49 inches in diameter, and upon the principle that the squares of the diameters of the conduit tubes are as the squares of the diameters of the ajutages multiplied by the square roots of the altitude of water in the reservoir. These experiments are considerably at variance with those made in the foregoing tables, in Southwark, &c., especially while water is being drawn for other purposes; they were probably made under circumstances considerably differing from the ordinary demands of practice.

Height of Jet.	Height of Reservoir.	Dis. per min. from ajutage .53-inch diameter.	Diam. of services suited to preceding column.
Feet.	Feet.	Cubic Feet.	Inches.
5.32	5.41	0.89	1.87
10.68	11.00	1.25	2.31
15.97	16.77	1.55	2.49
21.30	22.71	1.80	2.76
26.62	28.84	2.03	2.93
31.95	35.14	2.25	3.02
37.27	41.62	2.44	3.20
42.60	48.27	2.64	3.29
47.92	55.11	2.80	3.38
53.25	62.12	3.00	3.47
58.57	69.31	3.17	3.56
63.90	76.68	3.33	3.65
69.22	84.22	3.47	3.74
74.55	91.94	3.64	3.83
79.87	99.84	3.78	3.91
85.20	107.91	3.94	4.00
90.52	116.17	4.08	4.09
95.85	124.60	4.22	4.18
101.17	133.21	4.39	4.27
106.50	141.99	4.53	4.36

FIRE ENGINE POWER.

The best form of London engine has two cylinders of 7 inches diameter and 8 inches stroke, working levers being 4½ to 1; weight 17½ cwt. + 4 cwt. for hose and tools, which is quite as heavy as two fast horses can manage, for a distance under 6 miles, with five firemen and a driver.

The rule for determining the size of the jet, is to make its diameter one-eighth of an inch for every inch diameter of the cylinder for each 8 inches of stroke. When it is necessary to throw the water to an unusual height or distance, a jet one-seventh less in area is used, with a branch about 5 feet long.

The usual rate of working an engine this size is 40 strokes of each cylinder per minute, the engine throwing 14.12 cubic feet per minute, or, adding one-third for waste, 6,777 cubic feet required for 6 hours; this multiplied by the number of engines used, will give an idea of the quantity of water required at a fire. When the houses of Parliament were burnt down, 522,720 cubic feet of water was supplied, and 23 jets were playing at one time.

With *40 feet of leather hose, and a ⅞-inch jet, the pressure is* 30 *lbs. on the square inch* = 68 *feet head of water;* this gives 10.4 lbs. to each man to move a distance of 226 feet in one minute. The friction for every additional 40 feet of hose increases the labour 2½ per cent.; hence the necessity of having the engine, and of course the supply of water, close to the fire.—(Braidwood, &c. *Min. Inst. Civ. Engrs.*)

Steam Fire Engines, capable of throwing a great volume of water, have recently been introduced; it is probable that before many years have passed hand engines will be, to a great extent, superseded in all large towns.

FRICTION OF BENDS.—Table 9.

DESCRIPTION OF THE TABLE.

This table is computed on the formula $h = v^2 \times \sin^2 \times$ No. of bends $\times$ .0003, given in Robison's "Treatise on Rivers," where v is the velocity of water in a pipe or stream, expressed in inches per second; or in words; multiply the square of v by the sum of the squares of the sine of the angle of bends (of which the resistance is to be estimated) and the product by the constant .0003; the result expresses the resistance h = the head in inches necessary to overcome the angular friction, which varies as the square of the velocity and of the sine of the angle of bend with the straight line of direction. When the angle is reversed, or more than 90°, the square of the sine of the complementary angle + 1 must be used. The rule was adopted by Robison, from French experiments made upon pipes of small diameter, and he shews its applicability to rivers, giving an opinion that the measure of resistance is too great, as "in a pipe the diameter is uniform, whereas in a properly formed river "the capacity of section should be increased." This, theoretically, is true; but, practically, it is certain that both in natural and artificial rivers the effect of bends is invariably to render the bed more or less uneven. Under all the considerations, we may, therefore, come safely to the conclusion that the friction of bends, even where a drain is kept in good order, is at least as high as the amount given in the table.

The velocity for computation is of course that theoretically due to the

fall, and the loss by bends must be deducted from the head, the discharge being again calculated from the reduced slope. The loss of head, however, manifestly varies not only according to the size of the angle, but also to the volume to be carried. Applying the principles adopted in the former tables, the variable term of resistance will be best expressed by the square root of the hydraulic mean depth in feet, and the loss of head should be divided by this quantity to give the final resistance. By this form of the equation, when the hydraulic mean depth falls below unity, the tabular numbers are increased as the square of such depth. With pipes, this quantity being one-fourth of the diameter, the increase of resistance h will be $= \frac{v^2 \times \text{sine}^2 \times \text{No. of bends} \times .0003}{\sqrt{\frac{d}{4}}}$. This modification in the formula is new, and the whole computation is highly theoretical; but it sufficiently agrees with experiments and with observation, to be worthy of note. The principle of the correction is well founded where bends are uniform; but when they are made at sharp angles, the experiments of Mr. Rennie clearly show that they are out of the reach of calculation.

For application, take the second example at the head of Table 9, and applying it to a drain having six feet depth, 18 feet bottom, and 2 to 1 slopes, we find, by Table 4, that with a velocity of 110 feet per minute, such a cut will discharge 19,803 cubic feet per minute, and require six inches per mile of fall; we have then, for the bends specified, to make a reduction (in round numbers) of one inch fall per mile, if they occur in that length; but this quantity will have to be divided by 2, which is the square root of the hydraulic mean depth of the drain in question. Therefore, to deliver the same quantity of water, the drain must have 6.5 inches fall in the mile; or, *vice versa*, if the fall is limited, the effective slope will be reduced to 5.5 inches per mile, and the discharge to 18,915 cubic feet per minute, with a mean velocity of 105 feet per minute, instead of 110 feet, as originally assumed.

Bends in the vertical plane of a pipe are subject to disturbance of the discharge from two other causes, which will interfere far more than the dynamical effect of change of direction. The first is the great tendency to collection of air at the summit of vertical bends; this evil can only be treated mechanically, by air valves, which will free themselves, or can be opened at the pleasure of the water officer. The second defect in vertical bends is when, from local circumstances, they occur on a pipe at any given distance B, from the fountain head A; this point not being sufficiently high above B to pass the full quantity of water which could otherwise pass on to a lower point C; under these conditions it will be impossible for the pipe to discharge at C the amount due to its diameter, and to the *total fall from* A *to* C; and neither can the fall be fully available from B to C, because there will not be sufficient feed at B. This obviously shews that under these circumstances the pipe A B must be larger than B C; neglect of such a precaution has frequently produced serious disappointments; excellent provisions against the evils above stated were made by Mr. Jardine, of Edinburgh, in the great main, ten miles in length, which he constructed in 1824; the diameter for the upper three miles, being flat, is 21 inches, but that of the lower portion is only 15 inches; the actual discharge at Edinburgh is not greater than would be given by a pipe only the smaller diameter, with a *uniform fall for the entire distance.* This main was one of the earliest works in iron on so great a scale, and the whole arrangement is a model of its kind: at the present price of iron, such a work would not cost more than one-third of the amount then disbursed, but the value of this kind

of construction may be judged from the fact that this main has not cost anything whatever in repairs, and has never ceased delivering water from the day it was finished up to this date.

Other causes will arise to lessen discharge, unless due precautions are taken in the form of inlet and outlet of pipes, which will evidently affect the final delivery. The preceding rules and tables will meet all ordinary cases of practice, if the work is well laid out, and care is taken to avoid sharp angles and vertical bends, rising near to the level of the original head. If the form of nozzles or sluices starting from a reservoir is bad, the calculated discharge will be diminished in Eytelwein's proportion of 8 to 6 or 5, however much labour or money be spent on the general line of works. (For further information on this subject, see Leslie's paper, before quoted. *Min. Inst. Civ. Eng. Vol.* XIV., 1854-5, and other theoretic works.)

River Bends are especially liable to banks or shoals, always occurring where an alteration of velocity is suddenly caused; these shoals act as weirs, in point of fact, forming separate steps in the surface fall, and thus rendering a great aggregate slope of less value than a very small slope, with uniform bed. The effect, therefore, of bends, and want of uniformity, is of the highest inconvenience in rivers (like the Severn, below Gloucester, for instance) where there is a great fluctuation in the quantity of water, and a shifting material in the bed of which it is composed. The uneven bed of a river is very analogous to the defect from bends in the vertical plane, in the case of pipes.

FRICTION OF BRIDGES AND PIPES.—Tables 9a.

The first table is explained thereon, as giving an approximate idea of the rise of water caused by bridges, weirs, &c., at varying velocities; taking the proportions of obstruction from one-tenth to six-tenths of the whole section of river.

The second table is that used by Smeaton, giving the head required to drive water at various velocities through 100 feet lineal of pipes; on a small scale the table is useful; but our Tables 8 and 8*a* will give a greater range of results, and agree more with the modern practice of laying mains, and their sizes and material.

MOTION AND RESISTANCE OF WATER AND AIR. —Tables 10 and 10a

Give the resistance to one square foot, moving through water or air at stated velocities and angles, taken from Hutton's experiments, detailed in his tracts.

EXPANSION OF WATER, STEAM AND GAS.—Table 11

Gives the density of water and rate of expansion of steam at varying degrees of heat, from the best authorities. The figures in the tables are ratios to that quantity which is expressed by 1.00; they may, therefore, be applied to any measure. The expansion for gas is applicable to air, or any other gaseous fluid; the conditions of pressure or density being the same in parallel cases. (*Vide* Peclet, Regnault, and the Franklin Institute Experiments.)

VALUE OF WATER POWER.—Table 12.

This table gives the nominal value in horse power for one foot of fall, of streams discharging from 5 to 10,000 cubic feet per minute; *i. e.* the weight in pounds of the given number of cubic feet, per minute, divided by the constant 33,000. The effective value of the ordinary applications of water is given according to the best authorities. In estimating the value of a given quantity and fall of water, the mode of application, and therefore the commercial effect, will vary considerably; for in low falls under-shot or breast-wheels must be used, which are far more wasteful of water than over-shot wheels (in proportion to the power developed), especially when liable to be loaded with tail-water. The column headed "Turbine" is computed at 75 per cent. of the nominal power, or actual weight of water consumed. The "turbine," and some very perfectly constructed over-shot wheels are said to do this amount of duty; the usual duty of good water-wheels is from 60 to 65 per cent. in practice.

THE FOLLOWING TABLE of Water-Wheels, as constructed by Mr. Fairbairn, of Manchester, will afford a useful practical example of the best applications of Water Power. (Jamieson's *Practical Mechanic.*)

Fall of Water	Cubic Feet of Water taken per Min.	Diam.	Breadth	Depth of Bucket.	Revols per Min.	Speed of Periphy per Min.	Esti-mated Horse Power	Diam. of internal Driving Sgment	Breadth and Pitch of Teeth.
Ft. In.		Ft. In.	Ft. In.	Ft. In.	Ft. Dec	Ft. Dec.		Ft. In.	In.
..	...	65 0	6 0	1 0	...	...	...	63 3	10×3½
33 2	...	36 0	16 7	1 4	1.95	214.8	...	33 8	14×3
26 6	...	28 0	13 0	1 10	...	...	...	...	...
16 6	2760	20 0	17 0	1 8	...	229.2	60	18 0	12×3½
13 3	...	18 0	21 0	1 8	4.78	270.0	...	16 1	14×3
16 0	2160	18 0	20 0	1 6	...	...	52	...	...
10 0	...	18 0	18 0	1 10	6.15	339.6	...	14 0½	12×3
16 0	1200	18 0	12 0	1 5	...	...	30	...	...
9 0	6960	16 0	21 0	2 0	...	...	70	14 0½	...
7 10	...	16 0	20 0	1 9	7.8	384.6	...	15 4½	8×3
9 6	2700	16 0	18 0	1 8	...	330.0	...	14 0	12×3
...	...	16 0	16 0	2 0	...	...	...	14 0	12×3
8 0	...	16 0	14 9½	1 9	...	375.0	...	14 0½	9×3
8 0	...	15 6	17 6	1 8	...	332.4	...	...	...
14 6	480	15 0	6 0	0 10	...	...	12	...	...

THE FOLLOWING TABLE is compiled from a tract, by Weale, of experiments by the late Mr. Rennie, made about sixty years since. It was kindly put into the author's hands by George Rennie, Esq., F.R.S., the author of well-known works on hydraulics, which have been highly useful in compiling this treatise. The principal value is to shew the actual water used by the variously-constructed wheels, as the water used appears to have been measured with great care.

Name and Description of Mill.	Fall of Water	Water Wheel.				Mode of taking Water.		Water actually used per Min.	Horse Power.	
		Speed per Min.	Diam.	Brdth	Dpth of Beket	Head	Sluice open.		Nominal.	Effective.
	Ft. In.	Feet.	Ft. In.	Ft. In.	Ins.	Ft. In.	Ins.	C. Ft.		
Dartford, Saw	5 0	556.1	16 0	4 6	15	2 9	...	3,000	12.	
Ousburn, Oil	15 6	270.5	15 0	2 6	9	1 6	4	194.4	5.73	
Balbirnie, Water	19 6	432.2	22 0	4 0	10	...	...	257.0	9.78	6.07
Ficket, Paper	6 5	400.0	13 6	3 7	10	1 5	9	1290	15.73	
Tamworth, do., 1785	5 6	515.3	15 0	3 0	16	...	14.5	2444	23.23	6.86
Elford, do.	4 9	543.1	14 0	3 9	14	4 7	10.5	2199	24.73	5.50
West Bromwich, Forge*	10 0	1082.3	14 0	2 10	12	6 8½	7	1341	25.48	8.90
Bromwich, Slitting	...	826.5	18 0	4 4½	9	2 4	3	430	..	
Hunslet, do.	8 2	810.5	12 0	3 10	15½	5 1	28	93	10.48	
Isleworth, Flour†	11 6	361.2	19 4	6 0	12	0 8½	...	58		

* Hammer 7 Cwt., 106 blows per min., 20″ high. † 12.74 lbs. ground per min.

THE FOLLOWING EXPERIMENTS on a small Hydraulic Ram were made by Messrs. Hunter and English, of Bow. The effective duty appears to be about 50 per cent.

Fall of Rain.	Water expended.	Quantity lifted.	Height lifted.	Time occupied.
Feet.	Gallons.	Gallons.	Feet.	Minutes.
9.32	515	68	40.93	14
9.41	493	68	40.84	20
9.33	530	68	40.92	14
9.31	504	68	40.94	21
9.32	514	68	40.93	22

NOTE.—The height from the outlet of the ram to the top of the stand pipe is 50.25 feet; therefore the fall in feet deducted from this will give the height to which the water was raised above the head. The difference in time of filling the cistern is owing to variations in the adjustment of the beat of the valve,—slow motion giving the best duty.

PRESSURE OF MERCURY and WATER.—Table 13,

WEIGHT and STRENGTH OF PIPES.—Table 14,

Are sufficiently explained therein: in the latter table is given the safe head of water which can be borne by pipes of the several dimensions. It will he seen, that in smaller pipes the limit of thinness of metal is not strength, but the practicability of making a good casting, and its after durability. In large pipes, strength of metal should be thrown into the ends, especially the upper or socket end.

FLOOD DISCHARGES.—Table 15

Gives the quantity of water, in cubic feet per minute, which would run off the ground, assuming that the several depths of rain, specified at the head of each column, were to be discharged in twenty-four hours. The first table contains the quantities necessary to be provided for 1 to 100 acres, in farm drainage and in sewage of towns, where, under favourable circumstances, rain will occasionally discharge an enormous amount over small areas. For instance, during the thunder-storm of August 1, 1846, there fell over a great part of London from three to four inches of rain in a much less time than three hours; nearly the whole of this must have found its way at once into the sewers.

The second table contains the discharge for 1 to 10 square miles, from one thirty-second of an inch up to 1 inch of rain in twenty-four hours. In the numerous cases where an engineer is called upon to discuss the amount of water that he may expect over a given area, either for the purposes of town supplies, for estimating the scouring effect of floods, or for ascertaining the size required for new drains, or improvement of river-channels, this table will give a key to the problem to be solved, if used with a due experience of the observed quantities which districts have been known to produce, as compared with the amount collected in rain gauges. In the division of this work devoted to the subject of "Rivers and Flow from large Districts," will be found a number of examples, the application of which must be taken with due caution, because the quantity running away will vary according to the general slope of the country, and the geological nature of the rocks of which it is composed. Years having the same actual depth of rain in the gauge, vary in their stream-producing powers; one season is hot and dry, with heavy thunder showers; another is moist, with rain coming down frequently in small falls, supplying more for evaporation and less for streams.

FLOW FROM LARGE DISTRICTS.—Table 16

Gives the discharge from 1 acre and 1 square mile, due to stated amounts of rainfall, from 2 to 60 inches, supposing the whole to be run off at an equal average rate per minute, and per diem in one year. The second table gives the length of subsoil drain pipes required in 1 acre, the pipes being laid at intervals varying from 5 to 36 feet.

For extended information on the subjects comprised in Tables 15 and 16, see "Division II., on Rivers and Flow from large Districts."

EXPENDITURE OF WATER.—Table 17

Is arranged to shew readily the relation of cubic feet per minute with the same quantity in gallons for a minute, day, and year of 365 days.

THE FOLLOWING TABLE gives the value of water per annum, at a penny per 1,000 gallons, from 1 to 50 cubic feet per minute, and from 1,000 to 500,000 gallons per diem; the year being taken at 313 working days.

Cubic feet per Minute.	Gallons per Diem.	Value per Annum, at 1*d.* per 1,000 Gals.	Gallons per Diem.	Cubic feet per Minute.	Value per Annum, at 1*d.* per 1,000 Gals.
		£ s. d.			£ s. d.
1	9,000	11 14 9	1,000	0.111	1 6 1
2	18,000	23 9 6	2,500	0.277	3 5 2½
3	27,000	35 4 3	5,000	0.555	6 10 5
4	36,000	46 19 0	10,000	1.111	13 0 10
5	45,000	58 13 9	50,000	5.555	65 4 2
10	90,000	117 7 6	100,000	11.111	130 8 4
50	450,000	586 17 6	500,000	55.555	652 1 8

WATER SUPPLY AND POPULATION.—Table 18

Is arranged to give a ready measure of the quantity of water required to supply various amounts of population at different rates of consumption; with these are given the number of square miles of ground required at twelve inches of rain per annum. These data are given to guide, and not to lay down any rule upon the subject; we have found this form useful in judging of the capabilities of districts where there is absence of special data. In using these tables the information given in "Remarks on flow from large Districts" will be found useful, and reference may be made to the tables of "Metropolitan Water Supply," and of flow through "Metropolitan Sewers."—See Division II.

COMPARATIVE VELOCITIES, GRADIENTS, AND MEASURES.—Tables 19, 20, and 21,

Are arranged for ordinary reference, as explained thereon. Table 21 has also the angle of various rates of slope, and the difference of length between the base and hypotheneuse in each case.

USEFUL WEIGHTS AND MEASURES.—Table 22,

Contains a table shewing the decimal proportions of a foot or unity, in reference to a duodecimal division or inches; likewise the decimals which represent the ordinary fractions of an inch (or any other measure) from one-sixteenth to fifteen-sixteenths; thus, four inches and eleven-sixteenths, or 4.6875 inches, is .390 of a foot; these conversions are useful in computations of all kinds. The table has several other useful numbers, and the multipliers for converting the principal foreign measures into English equivalents.

Table 22a contains areas of segments of a circle, and lengths of their arcs; height of apparent above true level, for rotundity of the earth; square yards in decimals of an acre; and the number of bricks required for a given amount of work.

CONVERSION OF THERMOMETRIC SCALES AND OF ENGLISH AND FRENCH MEASURES.—Tables 23, 24, 25,

Are sufficiently explained in the headings and rules there given.

WEIGHT AND STRENGTH OF MATERIALS.—Tables 26, 27 and 28.

Tables 26 and 27 require no explanation beyond what will be found thereon. These tables have been collated from the best authorities, but rocks and earths, &c., will necessarily be found somewhat variable.

Table 28 gives the weight and breaking strain of iron, steel and copper wire according to the Birmingham wire gauge. The sizes of the gauges are as determined by the late Mr. Holtzapfell, and the weights

of iron and copper wire are from the experience of Mr. Lewis Gordon, civil engineer, and Mr. Johnson, of Manchester, wire drawer. The weights of copper wire are from Mr. Gordon, and Mr. Preece, civil engineer, kindly communicated by them to the author. A table is also given of the weights of equal sided angle and T iron, communicated by Messrs. Thomson and Browning, Victoria Street, Westminster; to all these gentlemen the author's thanks are due.

SUSPENSION BRIDGES.—Table 29

Gives the chief principles involved in catenary curves, and can be thus applied in all cases where the strength is required for suspended chains of any kind.

The strain in lbs. a rope will bear safely = girt^2 × 200
Do cable ,, = girt^2 × 120

Chain Cable.—Take the safe strain at about 8 tons per square inch of the iron of which it is made—*i.e.* four tons for each side of the link.

For really good chain, the proof weight should be 10 tons per square inch of each side of the link, and under this strain careful examination of the welds with the eye and hammer is necessary for thorough safety.

THE FOLLOWING IS A TABLE of the size and strength of Newall's wire rope.

Hemp Rope.		Wire Rope of Equivalent Strength.			
Circumference.	Weight per Fathom.	Circumference.	Weight per Fathom.	Breaking Strain.	Working Load.
Ins.	lbs.	Ins.	lbs.	Tons.	Cwts.
2¾	2	1	1	2	6
3¾	4	1½	2	4	12
4½	5	1⅞	3	6	18
5½	7	2⅛	4	8	24
6	9	2⅜	5	10	30
6½	10	2⅝	6	12	36
7	12	2⅞	7	14	42
7½	14	3⅛	8	16	48
8	16	3⅜	9	18	54
8½	18	3½	10	20	60
9½	22	3¾	12	24	72
10	26	4	15	28	48
11	30	4⅜	16	32	96

ROOFS AND LOCK GATES.—Table 30

Contains the tensile and compressive strains on the various members of roofs or trusses, at several angles; giving the proportions when the weight is unity. Also, the strain on three feet depth of surface of a lock gate in tons, and the size of oak timber necessary to bear three times the strain at different lengths of gate. This is from a paper by P. W. Barlow, Esq., C.E., in the first volume of the *Transactions of the Institution of Civil Engineers*. The strain is taken for gates placed at an angle of 19°.25′ with the square, which he shews to be the angle of greatest strength, taking all thrusts into consideration.

CAST IRON BEAMS.—Table 31

Gives the safe load to be borne by beams having the specified dimensions of bottom flange. This is constructed on Professor Hodgkinson's rule.

1. Multiply the area of the bottom flange by the depth of the beam, and divide the product by the length between supports (all in inches); the quotient multiplied by 514 will give the breaking weight at the centre.*
2. When a beam is uniformly loaded and supported at both ends, it will bear double the first result.
3. When a beam is fixed at one end and uniformly loaded, it will bear the same as the first result.
4. When a beam is fixed at one end and loaded at the other, it will bear only half the first result.

In the tables we have taken the safe load at one-third of the breaking weight; but for railway girders it should not exceed one-sixth, or half the tabular numbers. For safe deflection, a rough rule is—allow one-fortieth of an inch for each foot of span.

In ordinary wrought-iron beams we have found that the first rule is very fairly applicable, using a constant of 1,500 for the breaking weight. In general use, a beam of wrought iron should not be strained beyond one-third of its ultimate strength, but it has the advantage of being able to bear on an emergency two-thirds, without any serious damage; whereas this would be imminent risk with cast iron, especially with moving weight; hence the superiority of wrought iron where motion is likely to be freely communicated. No calculation of the strength of deep wrought-iron girders is safe, unless lateral stiffness be taken into the question. Within certain limits, increase of length of girder reduces the strength, in arithmetical proportion only, but the lateral stability of their sides varies as the fourth power of the effective mean thickness afforded by the stiffening ribs.

In long cast-iron beams, a proportion of six area of bottom flange to one area of the top flange will not give sufficient stiffness to the latter; with a wide bottom flange it is also necessary to have angle stays to secure it to the central web, and to insure continuity of strain through the vertical direction.

The depth of a beam may decrease at any point towards the extremities in the proportion of the multiples of the segments of its length;

* This rule is somewhat empirical, but it has the advantage of being below the mark.

thus, if a beam is 12 inches deep at the middle, and it is twenty feet in length, then at five feet from each bearing, the depth should be as $10 \times 10 : 15 \times 5 : : 12 : 9$ inches = required depth; but surplus strength and a thorough bed at the point of support are indispensable for security.

MARINE SURVEYING.—Table 32

Contains various tables useful for the nautical branch of the profession, especially in the use, for engineering purposes, of charts, which are generally constructed on astronomical measurement. The tide table is for computing rise or fall by time from high or low water, but Table 40 is more extended and accurate; the surveyor on the British coast will find the Admiralty Tide Tables to be his best guide; their usefulness is being extended every year.

THE FOLLOWING TABLE gives the variation of the compass for different latitudes and longitudes, for which we are indebted to Raper's Tables.

APPROXIMATE VARIATION OF THE COMPASS.

Lat. Deg.	W.	Longitude—East.											
	10	0	10	20	30	40	50	60	70	80	90	100	110
	W.	W.	W.	W.	W.	W.	W.	E.	E.	E.	E.	E.	E.
35	22	19	17	14	10	7	3	1	5	5	4	3	1
38	22	20	18	15	10	7	2	1	5	6	4	3	1
40	23	21	18	14	10	7	1	1	5	6	5	3	1
42	24	21	18	14	8	7	1	2	5	6	5	3	1
44	25	21	19	14	8	6	0	2	5	6	5	3	1
46	26	22	19	13	8	6	1E	3	5	7	5	3	1
48	27	22	19	13	8	5	1	3	5	7	5	3	1
50	27	23	20	12	8	5	1	4	6	7	6	3	1
52	28	24	20	12	8	5	2	4	6	7	6	3	1
54	29	24	20	12	8	4	2	5	6	8	7	4	1
56	30	25	20	13	8	4	2	5	7	8	7	4	1
58	21	25	20	13	8	4	2	5	7	8	7	4	2
60	32	26	19	13	8	3	3	5	8	8	8	5	2
62	34	27	19	13	8	3	2	5	8	9	8	5	3

MOUNTAIN BAROMETER.—Table 33.

This is a very useful instrument, when properly managed, for surveys and other geodesic operations which occasionally have to be made in districts where even the level and theodolite are useless until some idea of the line of country has been sketched out. In finding the relative summit levels of different gaps or passes in a mountainous country, we have used it with great advantage over ground which, in fact, was inaccessible to ordinary instruments, which must be used step by step.

For finding the height in feet, subtract the logarithm of the upper station from that of the lower; multiply by six, and remove the decimal point four places to the right; the result is the elevation in English feet, generally sufficiently accurate for purposes to which a mountain baro-

meter should be applied. If perfect accuracy be required in a fixed instrument, we have to correct the mercurial column, when the scale is of brass, by deducting the fraction, opposite the temperature (in degrees Fahrenheit) of the instrument, from the observations.

First, for the Mountain Barometer, we have the correction in Table B, *deducting*, if the upper station be coldest, the amount opposite the difference of temperature of the attached thermometers in degrees centigrade; or *adding* the amount if the upper station be the warmest.

Secondly, for the expansion of the air take the first correction and shift its decimal point three places to the left, and multiply it by twice the sum of the detached thermometer expressed in degrees centigrade; the product to be deducted or added as before.

Thirdly, for gravity the correction is to be added, as taken from Table C, according to the latitude and approximate height.

When an instrument having a cistern is used, we have the correction for capillarity in Table F, to be added to each observation before calculation; when a syphon barometer is used, we have no necessity for this correction.

Lastly, if fine and scientific observations are required, and accuracy is aimed at in hot weather and tropical countries, the observer should always have a portable dry and wet bulb thermometer; by this the original observations can be reduced to what they would be if the air at each station were perfectly dry. This is done by the rule in Table E, whence being obtained the temperature of the dew point, we can obtain the fraction to be deducted from the observation by Table D.

Example—Station A reads by Barometer 30.453 = 1.482950
„ B „ „ 29.341 = 1.466928

.016022

Then .01602 × 6 = .09612 and shifting the decimal point four places to the right the height of B above A is given = 961.2 feet.

But we will suppose that the temperature of the instrument at A is 27 cent.
„ „ „ „ B is 13 „

difference = 14 deg.

The correction in Table B for 14 degrees is 67.58.
The temperature of the air at A being..... 25 „
„ „ B „ ..... 14 „

For correcting the expansion of air; by the second rule we have .06758 to be multiplied by the double sum of the detached thermometers, or

.06758 × 78 = 5.27 feet.
add correction = 67.58 „

72.85 „
less..... 961.20 „
and adding for gravity... 2.80 „

corrected height ..... 891.15 feet.

If corrections for the aqueous vapour should be required, we will assume that at station A the dry bulb is 77 Fah.
wet bulb is 68 = diff. 9 deg. × 1.7 = 15.3 — 77 = 61.7 degrees for the dew point.
at station B the dry bulb is 57
wet bulb is 53 = diff. 4 deg. × 1.9 = 7.6 — 57 = 49.4 degrees for the dew point.

The correction then for these observations is thus :—

Station A Bar. reads.....	30.453
Less elastic force for 61.7 from Table D	.551
	29.902
Station B Bar. reads	29.341
force for 49.4 from Table D.....	.366
	28.975

We have then the true barometric heights which may be treated as given in the example..... } 29.902 for Station A. 28.975 for Station B.

Among the many varieties of mountain barometers, the standard one with leathern bag is only fit for observation at a fixed station, because continual use and setting of a large floating surface of mercury to an index renders the observations liable to error. The closed-cistern barometer, commonly called Englefield's, has the disadvantage of requiring a correction for the filling of the cistern, and we have also found these instruments sluggish in their action. The lightest and most philosophical instrument is Gay Lussac's; it requires no correction for capillary attraction, and having only to be read by the difference of the two legs of the syphon, there is an equal chance of index error in both readings.

A great superiority of this instrument is, that a magazine can always be carried, containing a number of spare tubes; and on a breakage, a new one can be put into the frame, and the instrument rendered again fit for use in a few minutes.

The Mountain Barometer is always arranged to read to 1,000th part of an inch, but we have generally found that two successive readings cannot be taken nearer than the third part of this quantity; excepting perhaps in the Gay Lussac, which can be inverted and read frequently, and not vary more than .002 in the result. No one travelling now should be without an aneroid or manometer, both of which are very susceptible, and little liable to damage; of course these require continual reference to a standard barometer. Negretti and Zambra have recently contrived a standard Mountain Barometer, without a bag, and otherwise superior to any instrument with which we have met.

MEAN READINGS OF THE BAROMETER.

As computed from Greenwich Observations, by James Glaisher, F.R.S.

Four times daily the reading of the barometer is at its mean value; these times in the several months are as follows:—

	h. m.		h. m.		h. m.	
In January.....at	midnight	... at	8 0	a.m. ... at	0 40	p.m. ... and at 5 0 p.m.
,, February ... ,,	midnight	... ,,	8 2	,, ... ,,	1 40	,, ... ,, 6 20 ,,
,, March ..... ,,	midnight	... ,,	7 35	,, ... ,,	1 50	,, ... ,, 6 0 ,,
,, April ..... ,,	1h. 0m.	a.m. ,,	6 40	,, ... ,,	1 40	,, ... ,, 7 20 ,,
,, May ..... ,,	1 0	,, ... ,,	8 20	,, ... ,,	1 0	,, ... ,, 8 0 ,,
,, June ..... ,,	midnight	... ,,	4 20	,, ... ,,	1 40	,, ... ,, 9 20 ,,
,, July ..... ,,	1h.0m.	a.m. ,,	6 25	,, ... ,,	1 40	,, ... ,, 8 45 ,,
,, August... .. ,,	1 0	,, ... ,,	7 0	,, ... ,,	1 10	,, ... ,, 7 35 ,,
,, September ,,	1 0	,, ... ,,	7 30	,, ... ,,	1 0	,, ... ,, 7 0 ,,
,, October..... ,,	0 25	,, ... ,,	7 50	,, ... ,,	1 10	,, ... ,, 5 0 ,,
,, November ,,	1 40	,, ... ,,	8 20	,, ... ,,	11 40	a.m. ... ,, 5 45 ,,
,, December ,,	0 40	,, ... ,,	7 40	,, ... ,,	0 45	p.m. ... ,, 6 5 ,,

That mean reading takes place with the greatest degree of steadiness which occurs between mid-day and 2 p.m.; the actual time varies, however, with the season.

MEAN READINGS OF THE THERMOMETER.

THE following table shews the corrections to be applied to the Monthly Mean of a thermometer (placed four feet above the soil, with its bulb freely exposed to the air, but in other respects protected from the influence of radiation and rain) at any hour, to deduce the true mean temperature of the air for the month from the observations taken at that hour; this table was compiled by Mr. Glaisher, from a long series taken at Greenwich.

Local mean time.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.
	°	°	°	°	°	°	°	°	°	°	°	°
Midnt	+1.0	+1.6	+2.9	+4.8	+5.4	+6.2	+5.0	+5.1	+4.0	+2.9	+1.7	+0.9
1 a.m	+0.9	+1.8	+3.0	+5.2	+6.0	+7.1	+5.5	+5.5	+4.5	+3.0	+1.8	+1.0
2	+1.2	+2.0	+3.3	+5.7	+6.4	+8.0	+6.0	+6.0	+5.5	+3.4	+2.0	+1.0
3	+1.3	+2.1	+3.6	+6.2	+6.7	+8.7	+6.4	+6.3	+6.4	+3.6	+2.0	+1.3
4	+1.6	+2.3	+3.9	+6.6	+6.7	+9.3	+6.6	+6.5	+6.6	+3.8	+2.1	+1.4
5	+1.8	+2.2	+4.0	+6.7	+6.3	+8.8	+6.2	+6.5	+6.2	+3.8	+2.0	+1.4
6	+1.9	+2.3	+3.9	+6.0	+4.8	+6.4	+4.5	+5.5	+5.3	+3.5	+1.9	+1.4
7	+1.9	+2.1	+3.6	+4.3	+2.6	+3.0	+2.5	+3.3	+4.0	+2.8	+1.7	+1.5
8	+1.5	+1.6	+2.5	+2.0	+0.5	0.0	0.0	+0.9	+2.1	+1.6	+1.0	+1.3
9	+1.0	+0.7	+0.2	−0.9	−2.0	−2.5	−2.0	−1.6	−0.4	0.0	+0.4	+0.9
10	+0.2	−0.5	−1.9	−3.2	−4.0	−4.5	−4.0	−3.5	−3.0	−2.0	−0.6	0.0
11	−1.3	−2.1	−3.5	−5.3	−5.5	−5.8	−5.4	−5.4	−5.0	−3.8	−2.0	−1.3
Noon.	−2.3	−3.2	−5.0	−6.8	−6.7	−7.3	−6.4	−6.5	−6.4	−5.1	−3.1	−2.1
1 p.m	−2.9	−3.9	−5.8	−7.9	−7.5	−8.1	−6.7	−7.5	−7.1	−5.5	−3.5	−2.4
2	−3.0	−3.9	−5.8	−8.2	−7.7	−8.6	−6.7	−7.7	−7.1	−4.9	−3.6	−2.3
3	−2.5	−3.6	−5.5	−7.7	−7.3	−8.4	−6.5	−7.0	−6.6	−3.7	−3.0	−1.9
4	−1.9	−2.8	−4.5	−6.7	−6.1	−7.4	−5.8	−5.5	−5.5	−2.8	−2.1	−1.3
5	−1.1	−1.6	−3.3	−5.4	−4.8	−6.1	−4.9	−3.6	−4.2	−1.7	−1.2	−0.8
6	−0.6	−0.6	−1.8	−3.5	−3.0	−4.5	−3.5	−2.0	−2.5	−0.8	−0.4	−0.4
7	−0.3	+0.3	−0.4	−1.1	−1.0	−2.4	−1.5	−0.5	−0.6	0.0	+0.1	−0.1
8	+0.1	+0.6	+0.9	+0.7	+0.9	0.0	+0.3	+1.0	+1.0	+0.7	+0.6	+0.2
9	+0.4	+1.0	+1.7	+2.0	+2.3	+1.8	+1.9	+2.4	+1.8	+1.3	+1.0	+0.4
10	+0.6	+1.3	+2.3	+3.2	+3.5	+3.6	+3.3	+3.3	+2.7	+1.9	+1.3	+0.5
11	+0.7	+1.5	+2.6	+4.1	+4.5	+5.0	+4.2	+4.3	+3.4	+2.4	+1.5	+0.8

The numbers are degrees Fahrenheit, and are to be added or subtracted as denoted by the signs.

To get the mean temperature truly, observations should be taken several times in the day, and at such times the algebraical sum of the corrections is a minimum.

Table II., shewing the corrections to be applied subtractively to the simple arithmetical mean of the maximum and minimum thermometers, to deduce from their readings the true temperature of the air;

	°		°
January	0.2	July	1.9
February	0.4	August	1.7
March	1.0	September	1.3
April	1.5	October	1.0
May	1.7	November	0.4
June	1.8	December	0.0

We have thus two easy methods of finding the true mean temperature; first, by taking observations several times a day, and applying corrections to their means from Table I.; and, secondly, by taking the half of the maximum and minimum readings and correcting it by the numbers in Table II.

At all places the form of the diurnal variation is a single progression, having one ascending branch and one descending branch, the maximum occurring early in the afternoon, and the minimum occurring at about

sunrise; but the amount of the difference of these extremes is variable, depending upon latitude, elevation, locality, and geological formation of the country.

If we compare the mean temperatures of places which differ considerably from each other in latitude, we shall find that the mean values are lower as we proceed north.

If we compare the mean temperatures of places having the same latitude, we shall find that the mean value of those situated at the higher level will be less than those at the lower level.

If we compare places having the same latitude, we shall find that the mean temperatures of those places situated inland will be higher in the summer months, and lower in the winter months, than those situated in the vicinity of the sea.

If we compare places differing only in their geological formations, we shall find that those places situated upon an arid, dry soil, will have a greater range of temperature than those situated upon a clayey, wet soil.

It is therefore possible that the corrections in Table I. may not be of universal application, but as the form of the curve described by the daily march is similar at all places, with the exception of being more or less bold, the turning points occurring at nearly the same local time, it is most probable that the amount of the correction applicable to any hour at any place, is the same part of the whole monthly mean daily range at that place, as the correction at Greenwich is of the monthly mean daily range at Greenwich.—*Excerpt Phil. Trans.* Part I, 1848.

See also "Glaisher's Meteorological Tables"—2nd Edition.

Tables 34, 35, 35a, 36, 37, 38,

Contain the area and circumference of circles; squares, cubes, square roots, cube roots, and reciprocals, 1 to 100; squares, square roots, and cube roots, 101 to 1,100; logarithms of number 1 or 100 to 1,000; logarithmic sines and cosines, 0 to 90 degrees for each 10 minutes; and natural sines, tangents, &c. &c.

These tables need no explanation here; they are inserted as collateral aid, in applying the tables to the various wants of the Engineer, as outlined in the foregoing pages; any further application of them will be obtainable from the ordinary works on the mathematical branches of the profession.

TIDE TABLES, 39, 39a, 39b, 40, 41.

These tables are chiefly based on the notes to the Admiralty tide tables, and information obligingly furnished by their superintendent, Mr. Burdwood; they will be found useful, not only for finding the heights and times of high water at the various ports mentioned, but also for tracing the progress of the tidal wave, and for readily ascertaining when any particularly high or low tide may be expected, by the rise attached to the different hours of the moon's transit and declination at noon.

Table 39 gives the constants for finding the *time* of high water at twenty-four places; no other corrections are given, as they are too small

to affect the validity of the result; a light breeze would occasion a greater variation than the largest correction that can be applied for time, and often for heights.

Table 39a gives the constants for finding the *heights* of high water *above the mean level of low water spring tides* at the same twenty-four places; for greater accuracy, the corrections for the moon's declination and parallax given in Table 39*b* must be applied.

Table 39b gives the corrections of height for the moon's declination and parallax for twenty places, which are to be applied to the constants previously found in Table 39*a*.

Tables 39 and 39*a* give the time and heights for a London tide two days following the transit, to be taken as a datum; for tides at the other specified places, take the additions shewn in these tables. But Portland is an exception, the time and heights for this place must be taken for a preceding transit. *Mean solar time* is used for all these tables; therefore, for *reducing all the times of the tables to common time*, correction must be made from an almanac according to the season.

EXAMPLE.—*Required the Time and Height of High Water at Hull, on January 24th*, 1852.

	D.	H.	M.
Moon's transit on January 22nd, at	0	1	13
Table 32 gives for 1h. 13m. at Hull	1	19	10
The time of high water following noon of Jan. 22nd or 8h. 23m. a.m, *mean solar time* on January 24th.	1	20	23

	Feet.
The same transit gives, by Table 32*a*	20.63
Correction for declination on January 22nd, viz., 18 deg.	—.16
,, parallax ,, viz., 55 min.	—.63
The height of high water, when corrected, being..... on January 24th, or 19 feet 10 ins, at 8.23 a.m.	19.84

Table 41 gives the mean spring range, and the constants of *time and heights* of high water, for a number of places, to be added or deducted, in reference to the standard places designated in black letters at the head of each division; the time and heights of these leading places being found from the tables 39, 39*a*, and 39*b*, in connection with the moon's transit and declination, as before described. It must be recollected that whatever the tide may range on the particular day required at the standard place, yet the constant difference at any other place, referred to such standard, will be the same; the places being in fact both situate on co-tidal lines.

EXAMPLE.—*Let it be required to find the Time and Height of High Water at Great Grimsby on the same date, viz., January 24th*, 1852.

	H.	M.	
Hull is the port of reference for Great Grimsby. The time of high water there, by the former example, is	8	23	a.m.
Constant for Great Grimsby .....——	0	53	
Giving for the time of high water	7	30	a.m.

	Ft.	In.
Height of high water at Hull on January 24th	19	10
Constant for Great Grimsby.....—	1	8
Giving for the height of high water	18	2

THE DEVONPORT TIDAL CONSTANTS, in Table 39*b*, were reduced by Dr. Whewell, from observations made at Devonport; the times being deduced from three, and the heights from five years' observations.

The method of using them is very similar to that of the other tables, but in order to make it clearer, an example is given below.

To find the Time and Height of High Water at Devonport, on January 26th, 1853.

	H.	M.
Moon's transit, January 24th	12	03
Table 396 gives	6	33
Time of high water, January 26th, being or 6h. 36m. a.m.	18	36

To find the height,—	Feet.
The above transit gives	15.37
Correction for declination, 23 deg.	.35
Height of water, January 26th, being	15.02

To find the Height of Low Water and the Range of the Tide.

The zero of tidal heights in Table 39*a*, is the mean height of low water at spring tides.

The low water of any one tide is generally as much above the *mean* low water as the high water of the same tide is below *mean* high water; and if the high water be above mean high water, the low water is as much below the zero of the tables.

EXAMPLE.—*Required the Height of Low Water and the Range of Tide at Hull, on January 24th*, 1852.

	Feet.
Height of high water as above	19.84
Mean height of high water at spring tides, above zero	20.83

Therefore high water on the 24th Jan., 1852, will be 0.99 below that of mean spring tide, and low water will be 0.99 above zero; therefore the range of the day will be $20.83 - .99 \times 2 = 18.85$ feet.

To find the height of the tide at say four hours from high water of the above day, take multiplier for four hours from Table 32*b*, which is $.258 \times 19.84$ feet $= 5.12$ feet above the low water of the day, which being .99 feet above zero of the tables, this is to be added to the above, making the height of the tide, at 4 hours ebb, 6.11 feet above zero of the tables. In contracted places and rivers, the tide flows faster than it ebbs, as will be seen in our various examples; this was also found to occur even throughout the Irish Sea, by Captain Beechey.

Table 40 shews the state of tide at each half-hour of rise or fall, for tides ranging from 6 to 40 feet; this will give by inspection a more accurate result than the foregoing rule. Further notes on this subject are given in the division of this work devoted to the subject of Tides and Tidal Rivers, particularly as to the diurnal inequality. There are many situations where the curves are not like this table, such as Portsmouth, Southampton, Portland, Severn and river tides generally.—*See Admiralty Tide Tables for* 1860.

Tables 42, 42a, 42b, and 42c, contain short abstracts for ascertaining the value of annuities, leases or reversions, with the fixed value of annuities by the Legacy Act. Those who require more particular information on this subject should consult "Inwood's Tables."

TABLE OF DISCHARGE FOR VARIOUS HEADS.

.02 to .80 Feet.

Column B, gives the natural or theoretic velocity in feet, per minute, acquired by water, or any other body, falling at the several heights in the column A.

Column C, gives the effective velocity of water passing through orifices of the form of the vena contracta—through bridges well constructed—through ordinary sluices with good side walls, and for very large sluices—through wide openings whose bottom is level with that of the reservoir. This column also gives the discharge through vertical pipes and narrow ill-built bridges, by deducting 1-9th from the product.

Column D, gives the effective velocity of water passing through sluices without side walls, such as used commonly upon mill-streams and rivers, undershot wheel-gates and canal-locks.

Rule.—Multiply the area of the orifice, in feet, by the discharge opposite the given height, either in column C or D, according to the nature of the case. See also page 1—2 for further uses.

A Head of Water.	B Natural Velocity.	C Effective Velocity.	D Effective Velocity.	A Head of Water.	B Natural Velocity.	C Effective Velocity.	D Effective Velocity.
Feet.	Feet per minute.	Feet per minute.	Feet per minute.	Feet.	Feet per minute.	Feet per minute.	Feet per minute.
				.41	308.48	288.0	192.1
.02	67.96	63.7	42.4	.42	312.33	291.6	194.4
.03	83.38	77.8	51.9	.43	316.04	295.1	196.7
.04	96.40	90.0	60.0	.44	319.56	298.3	199.0
.05	107.72	100.3	67.0	.45	323.42	301.9	201.2
.06	118.09	110.2	73.4	.46	326.79	305.1	203.4
.07	127.49	118.8	79.3	.47	330.41	308.5	205.6
.08	136.40	127.3	84.8	.48	334.02	311.8	207.8
.09	144.60	135.0	90.0	.49	337.40	315.0	210.0
.10	**152.31**	**142.2**	**94.8**	**.50**	**340.77**	**318.1**	**212.1**
.11	159.54	148.9	99.4	.51	344.15	321.3	214.2
.12	166.77	155.7	103.9	.52	347.52	324.4	216.3
.13	173.52	162.0	108.1	.53	350.89	327.6	218.4
.14	180.27	168.3	112.2	.54	354.27	330.7	220.4
.15	186.53	174.1	116.1	.55	357.16	333.7	222.5
.16	192.80	180.0	120.0	.56	360.53	336.6	224.5
.17	198.58	185.4	123.6	.57	363.91	339.7	226.5
.18	204.37	190.8	127.2	.58	367.04	342.7	228.4
.19	210.15	196.2	130.7	.59	370.17	345.6	230.4
.20	**215.45**	**201.1**	**134.1**	**.60**	**373.31**	**348.5**	**232.3**
.21	220.75	206.1	137.4	.61	376.44	351.4	234.3
.22	226.06	211.0	140.7	.62	379.33	354.1	236.2
.23	231.12	215.5	143.8	.63	382.56	357.1	238.1
.24	236.18	220.5	146.9	.64	385.60	360.0	240.0
.25	241.00	225.0	150.0	.65	388.49	362.7	241.8
.26	245.82	229.5	152.9	.66	391.38	365.4	243.7
.27	250.40	233.5	155.8	.67	394.27	368.3	245.5
.28	254.98	238.0	158.7	.68	397.45	371.0	247.4
.29	259.56	242.1	161.5	.69	400.35	373.8	249.2
.30	**263.99**	**246.4**	**164.3**	**.70**	**403.24**	**376.5**	**251.0**
.31	268.33	250.5	167.0	.71	406.13	379.2	252.8
.32	272.57	254.5	169.6	.72	408.97	381.8	254.5
.33	276.67	258.4	172.3	.73	411.62	384.3	256.3
.34	281.00	262.3	174.9	.74	414.52	387.0	258.0
.35	285.10	266.2	177.4	.75	417.41	389.7	259.8
.36	289.20	270.0	180.0	.76	420.06	392.2	261.5
.37	293.05	273.6	182.4	.77	422.71	394.6	263.2
.38	296.91	277.3	184.9	.78	425.60	397.3	264.9
.39	300.77	280.9	187.3	.79	428.50	400.0	266.6
.40	**304.62**	**284.5**	**189.7**	**.80**	**430.91**	**402.3**	**268.3**

TABLE OF DISCHARGE FOR VARIOUS HEADS.

.81 to 250. Feet.

A Head of Water.	B Natural Velocity.	C Effective Velocity.	D Effective Velocity.	A Head of Water.	B Natural Velocity.	C Effective Velocity.	D Effective Velocity.
Feet.	Feet per minute.	Feet per minute.	Feet per minute.	Feet.	Feet per minute.	Feet per minute.	Feet per minute.
.81	433.80	405.00	270.00	7.25	1298.02	1211.8	807.9
.82	436.21	407.5	271.6	7.50	1320.20	1232.5	821.7
.83	439.10	409.9	273.3	7.75	1341.89	1252.8	835.2
.84	441.51	412.4	274.9	8.00	1363.09	1272.6	848.4
.85	444.40	414.9	276.6	8.25	1384.30	1292.4	861.6
.86	446.81	417.1	278.2	8.50	1405.03	1311.7	874.5
.87	449.56	420.6	279.8	8.75	1425.75	1331.1	887.4
.88	452.11	422.1	281.4	9.00	1446.00	1350.0	900.0
.89	454.52	424.3	282.9	9.25	1465.76	1368.4	912.3
.90	**457.22**	**426.9**	**284.5**	**9.50**	**1485.52**	**1386.9**	**924.6**
.91	459.83	429.3	286.1	9.75	1504.80	1404.9	936.6
.92	462.24	431.5	287.7	10.00	1524.08	1422.9	948.6
.93	464.65	433.8	289.2	10.25	1543.36	1440.9	960.6
.94	467.06	436.3	290.8	10.50	1561.68	1458.0	972.0
.95	469.76	438.6	292.3	10.75	1580.47	1475.5	983.7
.96	472.21	440.8	293.9	11.00	1598.79	1492.6	995.1
.97	474.77	443.2	295.4	11.25	1616.62	1509.3	1006.2
.98	477.18	445.5	296.9	11.50	1634.46	1525.9	1017.3
.99	479.59	447.7	298.4	11.75	1652.29	1542.6	1028.4
1.00	**482.00**	**450.0**	**300.0**	**12.00**	**1669.648**	**1558.8**	**1039.2**
1.10	505.62	472.0	314.6	12.25	1687.00	1575.0	1050.0
1.20	527.79	492.7	328.6	12.50	1703.87	1590.7	1060.5
1.25	538.87	503.1	335.4	12.75	1721.22	1606.9	1071.3
1.30	549.58	513.0	342.0	13.00	1737.61	1622.2	1081.5
1.40	570.20	532.3	354.9	13.25	1754.48	1638.0	1092.0
1.50	590.30	551.1	367.4	13.50	1770.86	1653.3	1102.2
1.60	609.73	569.2	379.5	13.75	1787.25	1668.6	1112.4
1.70	628.52	586.8	391.1	14.00	1803.64	1683.9	1122.6
1.75	637.68	595.3	396.8	14.25	1819.55	1698.7	1132.5
1.80	**646.60**	**603.7**	**402.5**	**14.50**	**1835.45**	**1713.60**	**1142.4**
1.90	664.19	620.1	413.5	14.75	1850.88	1728.00	1152.0
2.00	681.55	636.3	424.2	15.00	1866.78	1742.85	1161.9
2.10	699.86	652.5	434.7	15.50	1897.63	1771.65	1181.1
2.20	714.80	667.3	444.9	16.00	1928.00	1800.00	1200.3
2.25	723.00	675.0	450.0	16.50	1957.88	1827.90	1218.6
2.30	730.95	682.4	454.9	17.00	1987.28	1855.35	1236.9
2.40	746.62	697.0	464.7	17.50	2016.20	1882.35	1254.9
2.50	762.04	711.4	474.3	18.00	2045.12	1909.35	1272.9
2.60	776.98	725.4	483.7	18.50	2073.08	1935.45	1290.3
2.70	**791.92**	**739.3**	**493.9**	**19.00**	**2101.03**	**1961.55**	**1307.7**
2.75	799.15	746.1	497.5	19.50	2128.51	2007.20	1324.8
2.80	806.38	752.8	502.0	20.00	2155.50	2012.40	1341.6
2.90	820.84	766.3	510.9	25.00	2410.00	2250.00	1500.0
3.00	834.82	779.5	519.6	30.00	2639.91	2464.65	1643.1
3.25	869.04	811.3	540.9	35.00	2851.51	2662.20	1774.8
3.50	901.82	841.9	561.3	40.00	3048.16	2845.80	1897.2
3.75	933.15	871.2	580.8	45.00	3233.25	3018.60	2012.4
4.00	964.00	900.0	600.0	50..0	3408.22	3181.95	2121.3
4.25	993.40	927.4	618.3	55.00	3574.51	3337.2	2224.8
4.50	**1022.32**	**954.4**	**636.3**	**60.00**	**3733.57**	**3485.7**	**2323.8**
4.75	1050.76	981.0	654.0	65.00	3885.88	3627.9	2418.6
5.00	1077.75	1006.2	670.8	70.00	4032.41	3764.70	2509.8
5.25	1104.26	1030.9	687.3	75.00	4174.12	3897.0	2598.0
5.50	1130.29	1055.2	703.5	80.00	4311.00	4024.80	2683.2
5.75	1155.83	1079.1	719.4	85.00	4443.55	4148.5	2765.7
6.00	1180.42	1102.0	734.7	90.00	4572.73	4269.1	2846.1
6.25	1205.00	1125.0	750.0	95.00	4698.05	4386.1	2924.1
6.50	1228.62	1149.0	764.7	100.00	4820.00	4500.0	3000.0
6.75	1252.23	1169.1	779.4	200.00	6816.44	6163.90	4242.6
7.00	**1275.37**	**1190.7**	**793.8**	**250.00**	**7615.0**	**7110.00**	**4740.0**

WEIRS OR OVERFALLS.—TABLE 2.

DISCHARGE,

IN CUBIC FEET PER MINUTE FOR ONE FOOT IN LENGTH.

RULE.—*Multiply the Quantity in the Table, opposite the given depth, by the length of the Weir in Feet; using Decimals for Fractional Parts.*

Depth falling over.	Discharge per Minute.	Depth falling over.	Discharge per Minute.	Depth falling over.	Discharge per Minute.
Feet.	Cubic Feet.	Feet.	Cubic Feet.	Feet.	Cubic Feet.
.01	0.21	.51	77.94	1.01	217.22
.02	0.61	.52	80.24	1.02	220.45
.03	1.11	.53	82.57	1.03	223.70
.04	1.71	.54	84.92	1.04	226.97
.05	2.39	.55	87.29	1.05	230.25
.06	3.15	.56	89.68	1.06	233.54
.07	3.96	.57	92.09	1.07	236.86
.08	4.84	.58	94.53	1.08	240.19
.09	5.78	.59	96.98	1.09	243.53
.10	**6.77**	**.60**	**99.46**	**1.10**	**246.89**
.11	7.81	.61	101.95	1.11	250.26
.12	8.90	.62	104.47	1.12	253.65
.13	10.03	.63	107.01	1.13	257.06
.14	11.21	.64	109.57	1.14	260.48
.15	12.43	.65	112.15	1.15	263.91
.16	13.70	.66	114.74	1.16	267.36
.17	15.00	.67	117.36	1.17	270.83
.18	16.34	.68	120.00	1.18	274.31
.19	17.72	.69	122.66	1.19	277.80
.20	**19.14**	**.70**	**125.33**	**1.20**	**281.31**
.21	20.59	.71	128.02	1.21	284.83
.22	22.08	.72	130.74	1.22	288.37
.23	23.60	.73	133.47	1.23	291.92
.24	25.16	.74	136.23	1.24	295.49
.25	26.75	.75	139.00	1.25	299.07
.26	28.37	.76	141.79	1.26	302.67
.27	30.02	.77	144.59	1.27	306.26
.28	31.71	.78	147.42	1.28	309.91
.29	33.42	.79	150.26	1.29	313.54
.30	**35.16**	**.80**	**153.13**	**1.30**	**317.20**
.31	36.93	.81	156.00	1.31	320.87
.32	38.74	.82	158.90	1.32	324.55
.33	40.57	.83	161.82	1.33	328.24
.34	42.42	.84	164.75	1.34	331.95
.35	44.31	.85	167.70	1.35	335.67
.36	46.22	.86	170.67	1.36	339.41
.37	48.16	.87	173.66	1.37	343.16
.38	50.13	.88	176.66	1.38	346.92
.39	52.12	.89	179.68	1.39	350.70
.40	**54.14**	**.90**	**182.72**	**1.40**	**354.49**
.41	56.18	.91	185.77	1.41	358.30
.42	58.25	.92	188.84	1.42	362.12
.43	60.34	.93	191.93	1.43	365.95
.44	62.46	.94	195.03	1.44	369.79
.45	64.60	.95	198.15	1.45	373.65
.46	66.76	.96	201.29	1.46	377.53
.47	68.95	.97	204.44	1.47	381.41
.48	71.16	.98	207.61	1.48	385.31
.49	73.40	.99	210.80	1.49	389.22
.50	**75.66**	**1.00**	**214.00**	**1.50**	**393.14**

WEIRS OR OVERFALLS.—Table 2.

DISCHARGE,

IN CUBIC FEET PER MINUTE FOR ONE FOOT IN LENGTH.

Rule.—*Multiply the Quantity in the Table, opposite the given depth, by the length of the Weir in feet; using Decimals for Fractional Parts.*

Depth falling over.	Discharge per Minute.	Depth falling over.	Discharge per Minute.	Depth falling over.	Discharge per Minute.
Feet.	Cubic Feet.	Feet.	Cubic Feet.	Feet.	Cubic Feet.
1.51	397.08	2.01	609.83	2.51	851.00
1.52	401.03	2.02	614.39	2.52	856.08
1.53	405.00	2.03	618.95	2.53	861.17
1.54	408.97	2.04	623.53	2.54	866.29
1.55	412.96	2.05	628.12	2.55	871.41
1.56	416.97	2.06	632.72	2.56	876.54
1.57	420.98	2.07	637.34	2.57	881.68
1.58	425.01	2.08	641.96	2.58	886.83
1.59	429.05	2.09	646.60	2.59	891.99
1.60	**433.11**	**2.10**	**651.24**	**2.60**	**897.17**
1.61	437.17	2.11	655.90	2.61	902.35
1.62	441.25	2.12	660.57	2.62	907.54
1.63	445.34	2.13	665.25	2.63	912.74
1.64	449.45	2.14	669.94	2.64	917.95
1.65	453.56	2.15	674.64	2.65	923.17
1.66	457.69	2.16	679.35	2.66	928.40
1.67	461.83	2.17	684.08	2.67	933.64
1.68	465.99	2.18	688.81	2.68	938.89
1.69	470.16	2.19	693.55	2.69	944.15
1.70	**474.34**	**2.20**	**698.31**	**2.70**	**949.42**
1.71	478.53	2.21	703.08	2.71	954.70
1.72	482.73	2.22	707.85	2.72	959.99
1.73	486.95	2.23	712.64	2.73	965.29
1.74	491.18	2.24	717.44	2.74	970.60
1.75	495.42	2.25	722.25	2.75	975.92
1.76	499.67	2.26	727.07	2.76	981.25
1.77	503.94	2.27	731.90	2.77	986.59
1.78	508.21	2.28	736.74	2.78	991.93
1.79	512.50	2.29	741.60	2.79	997.29
1.80	**516.80**	**2.30**	**746.46**	**2.80**	**1,002.65**
1.81	521.11	2.31	751.34	2.81	1,008.03
1.82	525.44	2.32	756.22	2.82	1,013.42
1.83	529.77	2.33	761.11	2.83	1,018.81
1.84	534.12	2.34	766.01	2.84	1,024.22
1.85	538.48	2.35	770.93	2.85	1,029.63
1.86	542.85	2.36	775.86	2.86	1,035.05
1.87	547.24	2.37	780.79	2.87	1,040.48
1.88	551.63	2.38	785.74	2.88	1,045.92
1.89	556.04	2.39	790.70	2.89	1,051.38
1.90	**560.46**	**2.40**	**795.67**	**2.90**	**1,056.84**
1.91	564.89	2.41	800.65	2.91	1,062.31
1.92	569.33	2.42	805.64	2.92	1,067.80
1.93	573.79	2.43	810.64	2.93	1,073.29
1.94	578.25	2.44	815.64	2.94	1,078.78
1.95	582.73	2.45	820.66	2.95	1,084.29
1.96	587.22	2.46	825.69	2.96	1,089.81
1.97	591.72	2.47	830.73	2.97	1,095.34
1.98	596.23	2.48	835.78	2.98	1,100.87
1.99	600.75	2.49	840.14	2.99	1,106.42
2.00	**605.28**	**2.50**	**845.91**	**3.00**	**1,111.98**

WEIRS OR OVERFALLS.—TABLE 2a.

DISCHARGE,

IN CUBIC FEET PER MINUTE FOR ONE FOOT IN LENGTH,

When the Stream approaches the Weir with three different initial velocities.

Rule.—Multiply the Quantity in the Table, opposite the given depth, and under the assumed velocity, by the length of the Weir in feet; using Decimals for Fractional parts.

Depth falling over.	Discharge, with Initial Velocity per Minute.			Depth falling over.	Discharge, with Initial Velocity per Minute.		
	60 Feet.	120 Feet.	180 Feet.		60 Feet.	120 Feet.	180 Feet.
feet.	Cubic feet per Min.	Cubic feet per Min.	Cubic feet per Min.	feet.	Cubic feet per Min.	Cubic feet per Min.	Cubic feet per Min.
.02	1.00	1.71	2.48	.82	162.25	171.93	186.96
.04	2.34	3.63	5.10	.84	168.13	177.94	193.19
.06	3.96	5.74	7.86	.86	174.11	184.05	199.52
.08	5.81	8.03	10.76	.88	180.14	190.20	205.88
.10	7.86	10.48	13.79	.90	186.23	196.41	212.30
.12	10.11	13.09	16.95	.92	192.40	202.70	218.80
.14	12.53	15.85	20.22	.94	198.63	209.05	225.35
.16	15.12	18.76	23.62	.96	204.93	215.47	231.97
.18	17.86	21.79	27.11	.98	211.29	221.95	238.65
.20	**20.75**	**24.96**	**30.72**	**1.00**	**217.74**	**228.51**	**245.41**
.22	23.78	28.25	34.43	1.02	224.18	235.06	252.16
.24	26.90	31.62	38.21	1.04	230.73	241.73	259.03
.25	28.56	33.41	40.21	1.06	237.35	248.45	265.96
.27	31.91	37.00	44.25	1.08	244.02	255.24	272.94
.30	37.15	42.59	50.35	1.10	250.78	262.12	280.02
.32	40.80	46.46	54.58	1.12	257.59	269.04	287.13
.34	44.55	50.42	58.89	1.14	264.44	276.00	294.27
.36	48.42	54.49	63.30	1.16	271.35	283.02	301.46
.38	52.39	58.65	67.80	1.18	278.35	290.13	308.73
.40	**56.45**	**62.90**	**72.38**	**1.20**	**285.40**	**297.29**	**316.08**
.42	60.65	67.27	77.07	1.22	292.47	304.49	323.46
.44	64.90	71.72	81.83	1.24	299.64	311.75	330.90
.46	69.26	76.26	86.67	1.25	303.24	315.40	334.64
.48	73.71	80.88	91.59	1.27	310.47	322.73	342.15
.50	78.26	85.60	96.60	1.30	321.41	333.84	353.53
.52	82.90	90.41	102.60	1.32	328.83	341.33	361.21
.54	87.62	95.29	106.86	1.34	336.26	348.87	368.91
.56	92.44	100.27	112.11	1.36	343.75	356.46	376.67
.58	97.33	105.32	117.43	1.38	351.30	364.11	384.49
.60	**102.31**	**110.45**	**122.82**	**1.40**	**358.90**	**371.80**	**392.35**
.62	107.38	115.67	128.30	1.42	366.54	379.53	400.25
.64	112.52	120.96	133.85	1.44	374.24	387.32	408.21
.66	117.74	126.33	139.47	1.46	382.01	395.18	416.23
.68	123.05	131.64	145.03	1.48	389.84	403.10	424.32
.70	128.43	137.30	150.82	1.50	397.71	411.07	432.45
.72	133.88	142.75	156.62	1.52	405.64	419.10	440.64
.74	139.41	148.42	162.53	1.54	413.60	427.18	448.88
.75	142.20	151.42	165.03	1.56	421.61	435.29	457.15
.77	147.84	157.23	171.68	1.58	429.68	443.44	465.45
.80	**156.43**	**165.98**	**180.78**	**1.60**	**437.82**	**451.65**	**473.82**

DISCHARGE,

IN CUBIC FEET PER MINUTE FOR ONE FOOT IN LENGTH,

When the Stream approaches the Weir with three different initial velocities.

Rule.—Multiply the Quantity in the Table, opposite the given depth, and under the assumed velocity, by the length of the Weir in feet; using Decimals for Fractional parts.

Depth falling over.	Discharge, with Initial Velocity per Minute.			Depth falling over.	Discharge, with Initial Velocity per Minute.		
	60 Feet.	120 Feet.	180 Feet.		60 Feet.	120 Feet.	180 Feet.
feet.	Cubic feet per Min.	Cubic feet per Min.	Cubic feet per Min.	feet.	Cubic feet per Min.	Cubic feet per Min.	Cubic feet per Min.
1.62	446.00	459.92	482.25	2.42	811.42	828.60	856.44
1.64	454.21	468.23	490.73	2.44	821.46	838.71	866.68
1.66	462.50	476.61	499.26	2.46	831.54	848.86	876.95
1.68	470.82	485.02	507.82	2.48	841.66	859.05	887.26
1.70	479.19	493.48	516.42	2.50	851.83	869.29	897.62
1.72	487.62	502.00	525.09	2.52	862.01	879.54	908.00
1.74	496.09	510.56	533.80	2.54	872.24	889.84	918.43
1.75	500.35	514.86	538.17	2.56	882.51	900.18	928.89
1.77	508.89	523.48	546.94	2.58	892.83	910.57	939.40
1.80	**521.80**	**536.52**	**560.21**	**2.60**	**903.19**	**921.00**	**949.95**
1.82	530.46	545.27	569.09	2.62	913.59	931.48	960.55
1.84	539.17	554.07	578.03	2.64	924.02	941.98	971.17
1.86	547.34	562.93	587.02	2.66	934.49	952.52	981.83
1.88	556.74	571.81	596.04	2.68	945.00	963.10	992.53
1.90	565.60	580.75	605.12	2.70	955.55	973.72	1,003.27
1.92	574.50	589.73	614.25	2.72	966.15	984.38	1,014.07
1.94	583.45	598.77	623.42	2.74	976.78	995.90	1,024.90
1.96	592.44	607.83	632.64	2.75	982.13	1,000.48	1,030.34
1.98	601.47	616.94	641.90	2.77	992.79	1,011.25	1,041.27
2.00	**610.56**	**626.10**	**651.20**	**2.80**	**1,008.92**	**1,027.45**	**1,057.58**
2.02	619.68	635.30	660.55	2.82	1,019.69	1,038.29	1,068.54
2.04	628.86	644.56	669.95	2.84	1,030.52	1,049.19	1,079.56
2.06	638.08	653.86	679.39	2.86	1,041.37	1,060.11	1,090.60
2.08	647.33	663.19	688.86	2 88	1,052.26	1,071.06	1,101.66
2.10	656.64	672.58	698.39	2.90	1,063.19	1,082.05	1,112.76
2.12	665.99	682.01	707.95	2.92	1,074.17	1,093.10	1,123.93
2.14	675.38	691.48	717.56	2.94	1,085.19	1,104.18	1,135.13
2.16	684.82	701.00	727.21	2.96	1,096.23	1,115.28	1,146.35
2.18	694.32	710.58	736.92	2.98	1,107.32	1,126.43	1,157 61
2.20	**703.85**	**720.18**	**746.65**	**3.00**	**1,118.45**	**1,137.62**	**1,168.89**
2.22	713.41	729.82	756.42	3.10	1,174.69	1,194.12	1,225.92
2.24	723.02	739.51	766.24	3.20	1,231.68	1,251.54	1,283.85
2.25	727.83	744.36	771.15	3.30	1,289.67	1,309.86	1,342.70
2.27	737.51	754.12	781.03	3.40	1,348.54	1,369.04	1,402.41
2.30	752.12	768.84	795.93	3.50	1,408.26	1,429.06	1,462.97
2.32	761.90	778.70	805.92	3.60	1,468.82	1,489.95	1,524.34
2.34	771.73	788.61	815.96	3.70	1,530.26	1,551.58	1,586.55
2.36	781.59	798.56	826.02	3.80	1,592.50	1,614.23	1,649.64
2.38	791.50	808.45	836.12	3.90	1,655.59	1,677.59	1,713.48
2.40	**801.45**	**818.55**	**846.26**	**4.00**	**1,719.47**	**1,741.70**	**1,778.12**

TABLE OF SURFACE, MEAN & BOTTOM VELOCITIES

OF

STREAMS, RIVERS AND TIDAL ESTUARIES.

From 5 to 200 Feet per Minute.

RULE.—*The first column represents the average surface velocities at the middle of a river. Any corresponding mean velocity, when multiplied by the area, will give the discharge in cubic feet, per minute. The bottom velocities represent the action on the sides and bottom of any stream, pipe, or culvert, whose mean velocity is known.*

NOTE.—For velocities in inches, per second, divide the tabular numbers by 5.
For miles per hour, multiply the tabular numbers by .01136.

Surface Velocity.	Mean Velocity.	Bottom Velocity.	Surface Velocity.	Mean Velocity.	Bottom Velocity.
Feet ℘ Minute.	Feet ℘ Minute.	Feet ℘ Minute.	Feet ℘ Minute.	Feet ℘ Minute.	Feet ℘ Minute.
			102.5	82.35	62.2
5.	2.50	.0	105.	84.60	64.2
7.5	3.90	.3	107.5	86.80	66.1
10.	5.45	.9	110.	89.05	68.1
12.5	7.10	1.7	112.5	91.30	70.1
15.	8.85	2.7	115.	93.55	72.1
17.5	10.65	3.8	117.5	95.75	74.0
20.	**12.50**	**5.0**	**120.**	**98.00**	**76.0**
22.5	14.40	6.3	122.5	100.25	78.0
25.	16.35	7.7	125.	102.50	80.0
27.5	18.30	9.1	127.5	104.75	82.0
30.	20.25	10.5	130.	107.00	84.0
32.5	22.05	12.0	132.5	109.25	86.0
35.	24.30	13.6	135.	111.55	88.1
37.5	26.30	15.1	137.5	113.80	90.1
40.	**28.35**	**16.7**	**140.**	**116.05**	**92.1**
42.5	30.45	18.4	142.5	118.30	94.1
45.	32.50	20.0	145.	120.60	96.2
47.5	34.60	21.7	147.5	122.85	98.2
50.	36.70	23.4	150.	125.15	100.3
52.5	38.80	25.1	152.5	127.40	102.3
55.	40.95	26.9	155.	129.65	104.3
57.5	43.05	28.6	157.5	131.95	106.4
60.	**45.20**	**30.4**	**160.**	**134.20**	**108.4**
62.5	47.35	32.2	162.5	136.50	110.5
65.	49.50	34.0	165.	138.80	112.6
67.5	51.65	35.8	167.5	141.05	114.6
70.	53.80	37.6	170.	143.35	116.7
72.5	55.95	39.4	172.5	145.65	118.8
75.	58.15	41.3	175.	147.95	120.9
77.5	60.30	43.1	177.5	150.20	122.9
80.	**62.50**	**45.0**	**180.**	**152.50**	**125.0**
82.5	64.70	46.7	182.5	154.80	127.1
85.	66.90	48.8	185.	157.10	129.2
87.5	69.10	50.7	187.5	159.40	131.3
90.	71.30	52.6	190.	161.70	133.4
92.5	73.50	54.5	192.5	164.00	135.5
95.	75.70	56.4	195.	166.30	137.6
97.5	77.95	58.4	197.5	168.60	139.7
100.	**80.15**	**60.3**	**200.**	**170.90**	**141.8**

TABLE OF SURFACE, MEAN & BOTTOM VELOCITIES

OF

STREAMS, RIVERS AND TIDAL ESTUARIES.

From 202.5 to 950 Feet per Minute.

NOTE.—Bottom velocities—

30 feet per minute will not disturb clay with sand and stones.
40 " " will sweep along coarse sand.
60 " " " fine gravel.
120 " " " rounded pebbles.
180 " " " angular stones.

Surface Velocity.	Mean Velocity.	Bottom Velocity.	Surface Velocity.	Mean Velocity.	Bottom Velocity.
Feet ℘ Minute.	Feet ℘ Minute.	Feet ℘ Minute.	Feet ℘ Minute.	Feet ℘ Minute.	Feet ℘ Minute.
202.5	173.20	143.9	305	268.4	231.9
205.0	175.50	146.0	310	273.1	236.3
207.5	177.80	148.1	315	277.8	240.6
210.0	180.10	150.2	320	282.5	245.0
212.5	182.40	152.3	325	287.2	249.4
215.0	184.75	154.5	330	291.9	253.8
217.5	187.05	156.6	335	296.6	258.2
220.0	**189.35**	**158.7**	**340**	**301.2**	**262.5**
222.5	191.65	160.8	345	305.9	266.9
225.0	193.95	162.9	350	310.6	271.3
227.5	196.30	165.1	355	315.3	275.7
230.0	198.60	167.2	360	320.1	280.2
232.5	200.90	169.3	365	324.8	284.6
235.0	203.25	171.5	370	329.5	289.0
237.5	205.55	173.6	375	334.2	293.4
240.0	**207.85**	**175.7**	**380**	**338.9**	**297.8**
242.5	210.20	177.9	385	343.6	302.3
245.0	212.50	180.0	390	348.3	306.7
247.5	214.85	182.2	395	353.0	311.1
250.0	217.15	184.3	400	357.8	315.6
252.5	219.50	186.5	405	362.5	320.0
255.0	221.80	188.6	410	367.2	324.5
257.5	224.15	190.8	415	371.9	328.9
260.0	**226.45**	**192.9**	**420**	**376.7**	**333.4**
262.5	228.80	195.1	425	381.4	337.8
265.0	231.10	197.2	430	386.1	342.3
267.5	233.45	199.4	435	390.8	346.7
270.0	235.75	201.5	440	395.6	351.2
272.5	238.10	203,7	445	400.3	355.7
275.0	240.45	205.9	450	405.1	360.2
277.5	242.75	208.0	500	452.5	405.0
280.0	**245.10**	**210.1**	**550**	**500.0**	**450.1**
282.5	247.45	212.4	600	547.7	495.5
285.0	249.75	214.5	650	595.5	541.0
287.5	252.10	216.7	700	643.3	586.7
290.0	254.45	218.9	750	691.2	632.5
292.5	256.75	221.0	800	739.2	678.5
295.0	259.10	223.2	850	787.3	724.6
297.5	261.45	225.4	900	835.4	770.8
300.0	**263.75**	**227.5**	**950**	**883.6**	**817.2**

TABLE OF DISCHARGE AND VELOCITIES,

IN CUBIC AND LINEAL FEET PER MINUTE,

For Cuts of any kind at the Specified Rates of Fall per Mile, and with the Depths of Water and Bottom Widths stated in the First Column.

With Slopes of 2 to 1 throughout.

For the Discharge and Velocity of any Cut having a Fall per Mile of ..	In.	Take twice the Discharge & Velocity from the Columns respectively of	In.	For the Discharge and Velocity of any Cut having a Fall per Mile of ..	In.	Take half the Discharge and Velocity from the Columns respectively of	In.
	8		2		¼		2
	12		3		½		3
	16		4		1		4
	20		5		1¼		5
	24		6		1½		6
	36		9		2¼		9

FALL.		2 inches. per mile.		3 inches. per mile.		4 inches. per mile.		5 inches. per mile.		6 inches. per mile.		9 inches. per mile.	
	Bottom Widths Feet.	Discharge cubic feet.	Vel. feet.	Discharge cubic feet.	Vel. feet.	Discharge cubic feet.	Vel. feet.	Discharge cubic feet.	Vel. feet.	Discharge cubic feet.	Vel. feet.	Discharge cubic feet.	Vel. feet.
Depth 1.5 Feet.	3	275	30.6	336	37.4	389	43.2	435	48.3	476	52.9	578	64.3
	4	329	31.4	404	38.5	466	44.4	521	49.6	571	54.4	698	66.5
	5	385	32.1	471	39.3	541	45.3	609	50.8	666	55.5	811	67.6
	6	441	32.7	540	40.0	624	46.2	698	51.7	764	56.6	925	69.3
	7	498	33.2	609	40.6	703	46.9	787	52.5	858	57.2	1056	70.4
	8	554	33.6	680	41.2	784	47.5	876	53.1	960	58.2	1171	70.9
	9	612	34.0	749	41.6	866	48.1	966	53.7	1056	58.7	1296	72.0
	10	669	34.3	817	41.9	946	48.5	1057	54.2	1156	59.3	1416	72.6
	12	783	34.8	958	42.6	1007	49.2	1237	55.0	1354	60.2	1658	73.7
	14	897	35.2	1099	43.1	1270	49.8	1415	55.5	1555	61.0	1907	74.8
Depth 2.0 Feet.	3	477	34.1	585	41.8	677	48.4	759	54.2	831	59.4	1016	72.6
	4	561	35.2	686	42.9	798	49.9	888	55.5	976	61.0	1196	74.8
	5	642	35.7	794	44.1	918	51.0	1020	56.6	1118	62.1	1375	76.4
	6	726	36.3	900	45.0	1034	51.7	1114	57.2	1264	63.2	1556	77.8
	7	820	37.3	1003	45.6	1161	52.8	1295	58.8	1414	64.3	1729	78.6
	8	897	37.4	1109	46.2	1279	53.3	1425	59.4	1569	65.4	1912	79.7
	9	985	37.9	1214	46.7	1401	53.9	1557	59.9	1716	66.0	2101	80.8
	10	1081	38.6	1324	47.3	1523	54.4	1702	60.8	1862	66.5	2279	81.4
	12	1245	38.9	1529	47.8	1750	55.0	1968	61.5	2163	67.6	2656	83.0
	14	1429	39.7	1742	48.4	2019	56.1	2257	62.7	2473	68.7	3047	84.1
Depth 2.5 Feet.	3	754	37.7	922	46.1	1066	53.3	1176	58.8	1298	64.9	1594	79.7
	4	868	38.6	1064	47.3	1228	54.6	1372	61.0	1496	66.5	1842	81.9
	5	985	39.4	1207	48.3	1387	55.5	1552	62.1	1705	68.2	2090	83.6
	6	1103	40.1	1353	49.2	1556	56.6	1738	63.2	1905	69.3	2343	85.2
	7	1221	40.7	1497	49.9	1731	57.7	1929	64.3	2112	70.4	2589	86.3
	8	1339	41.2	1644	50.6	1894	58.3	2109	64.9	2323	71.5	2840	87.4
	9	1463	41.8	1561	51.2	2058	58.8	2310	66.0	2520	72.0	3097	88.5
	10	1582	42.2	1938	51.7	2227	59.4	2493	66.5	2741	73.1	3360	89.6
	12	1823	42.9	2235	52.6	2571	60.5	2873	67.6	3153	74.2	3880	91.3
	14	2071	43.6	2536	53.4	2926	61.6	3263	68.7	3576	75.3	4389	92.4

DISCHARGE AND VELOCITIES

IN CUBIC AND LINEAL FEET PER MINUTE.

At the following Rates of Fall.

FALL.		2 inches per mile.		3 inches per mile.		4 inches per mile.		5 inches per mile.		6 inches per mile.		9 inches per mile.	
	Bottom widths. Feet.	Discharge cubic feet.	Vel. feet.	Discharge cubic feet.	Vel. feet.	Discharge cubic feet.	Vel. feet.	Discharge cubic feet.	Vel. feet.	Discharge cubic feet.	Vel. feet.	Discharge cubic feet.	Vel. feet.
Depth 3.00 feet.	4	1245	41.5	1527	50.9	1764	58.8	1962	65.4	2160	72.0	2640	88.0
	6	1551	43.1	1904	52.9	2196	61.0	2455	68.2	2812	74.8	3287	91.3
	8	1865	44.4	2284	54.4	2633	62.7	2931	69.8	3234	77.0	3948	94.0
	10	2179	45.4	2664	55.5	3062	63.8	3432	71.5	3773	78.6	4617	96.2
	12	2495	46.2	3056	56.6	3504	64.9	3920	72.6	4304	79.7	5286	97.9
	14	2814	46.9	3432	57.2	3960	66.0	4622	73.7	4848	80.8	5940	99.0
	16	3135	47.5	3847	58.3	4428	67.1	4929	74.8	5405	81.9	6639	100.6
	18	3456	48.0	4233	58.8	4867	67.6	5465	75.9	5976	83.0	7322	101.7
	20	3783	48.5	4617	59.2	5319	68.2	5959	76.4	6521	83.6	8018	102.8
	25	4594	49.4	5626	60.5	6491	69.8	7263	78.1	7923	85.2	9718	104.5
Depth 3.50 feet.	6	2093	46.0	2552	56.1	2953	64.9	3303	72.6	3626	79.7	4427	97.3
	8	2483	47.3	3029	57.7	3491	66.5	3927	74.8	4273	81.4	5255	100.1
	10	2656	48.3	3534	59.4	4052	68.1	4516	75.9	4968	83.5	6087	102.3
	12	3271	49.2	3983	59.9	4608	69.3	5153	77.5	5672	85.3	6942	104.4
	14	3675	50.0	4483	61.0	5174	70.4	5777	78.6	6350	86.4	7754	105.5
	16	4073	50.6	4999	61.1	5755	71.5	6416	79.7	7043	87.5	8630	107.2
	18	4480	51.2	5486	62.7	6300	72.0	7070	80.8	7752	88.6	9476	108.3
	20	4885	51.7	5972	63.2	6908	73.1	7692	81.4	8420	89.1	10,338	109.4
	25	5913	52.8	7201	64.3	8310	74.2	9296	83.0	10,225	91.3	12,499	111.0
	30	6915	53.4	8404	64.9	9751	75.3	10,890	84.1	11,960	92.4	14,615	113.3
Depth 4.00 feet.	6	2565	45.8	3326	59.4	3847	68.7	4278	76.4	4710	84.1	5757	102.8
	8	3187	49.8	3904	61.0	4505	70.4	5030	78.6	5530	86.4	6752	105.5
	10	3672	51.0	4478	62.2	5184	72.0	5781	80.3	6336	88.0	7718	107.2
	12	4160	52.0	5104	63.8	5848	73.1	6552	81.9	7216	90.2	8800	110.3
	14	4646	52.8	5658	64.3	6529	74.2	7304	83.0	8034	91.3	9829	111.7
	16	5126	53.4	6278	65.4	7229	75.3	8073	84.1	8870	92.4	10,925	113.8
	18	5616	54.0	6864	66.0	7945	76.4	8871	85.3	9724	93.5	11,897	114.4
	20	6104	54.5	7448	66.5	8624	77.0	9609	85.8	10,528	94.0	12,936	115.5
	25	7339	55.6	9002	68.2	10,375	78.6	11,616	88.0	12,698	96.2	15,615	118.3
	30	8527	56.1	10,533	69.3	12,114	79.7	13,543	89.1	14,865	97.8	18,225	119.9
Depth 4.50 feet.	8	4005	52.3	4880	63.8	5638	73.7	6301	82.4	6946	90.8	8,500	111.1
	10	4565	53.4	5591	65.4	6438	75.3	7190	84.1	7800	92.4	9,687	113.3
	12	5140	54.4	6284	66.5	7276	77.0	8108	85.8	8883	94.0	10,915	115.5
	14	5692	55.0	6996	67.6	8052	77.8	9056	87.5	9905	95.7	12,130	117.2
	16	6311	56.1	7728	68.7	8842	78.6	9967	88.6	10,890	96.8	13,365	118.8
	18	6,864	56.5	8408	69.2	9683	79.7	10,825	89.1	11,895	97.9	14,568	119.9
	20	7,464	57.2	9109	69.8	10,544	80.8	11,771	90.2	12,920	99.0	15,790	121.0
	25	8,920	58.3	10,939	71.5	12,622	82.5	14,121	92.3	15,483	101.2	18,926	123.7
	30	10,424	59.4	12,741	72.6	14,672	83.6	16,409	93.5	18,041	102.8	22,095	125.9
	35	11,860	59.9	14,592	73.7	16,770	84.7	18,850	95.2	20,572	103.9	25,265	127.6

DISCHARGE AND VELOCITIES

IN CUBIC AND LINEAL FEET PER MINUTE,

At the following Rates of Fall.

FALL.		2 inches. per mile.		3 inches. per mile.		4 inches. per mile.		5 inches. per mile.		6 inches per mile.		9 inches per mile.	
	Bottom widths. Feet.	Discharge cubic feet.	Vel. feet.	Discharge cubic feet.	Vel. feet.	Discharge cubic feet.	Vel. feet.	Discharge cubic feet.	Vel. feet.	Discharge cubic feet.	Vel. feet.	Discharge cubic feet.	Vel. feet.
Depth 5.00 feet.	8	4896	54.	5985	66	6930	77	7767	86	8505	94	10395	115
	10	5560	55.	6810	68	7860	78	8800	88	9630	96	11830	118
	12	6215	56.	7612	69	8833	80	9867	90	10769	98	13244	120
	14	6924	57.	8448	70	9768	81	10884	91	11952	100	14628	122
	16	7579	59.	9295	71	10725	82	12012	92	13156	101	16055	123
	18	8232	58	10080	72	11704	83	13090	93	14322	102	17556	125
	20	8985	60	10965	73	12615	84	14100	94	15510	103	18960	126
	25	10675	61	12985	74	14997	86	16835	96	18462	105	22610	129
	30	12320	62	15180	76.	17480	87	19580	98	21440	107	26280	131
	35	14107	63	17325	77	19912	88	22275	99	24480	109	29947	133
Depth 6.00 feet.	10	7906	60	9649	73	11180	85	12474	94	13728	104	16830	127
	12	8784	61	10771	75	12441	86	13867	96	15192	105	18604	129
	14	9609	62	11840	76	13650	87	15272	98	16723	107	20498	131
	16	10533	63	12936	77	14884	88	16732	99	18276	109	22344	133
	18	11394	63	13950	77	16140	90	18018	100	19803	110	24246	135
	20	12249	64	15091	78	17433	91	19430	101	21331	111	26150	136
	25	14518	65	17826	80	20512	92	22954	103	25152	113	30880	139
	30	16758	66	20512	81	23688	94	26586	105	29106	115	35758	142
	35	19063	67	23265	82	26987	96	30230	107	33022	117	40467	143
	40	21278	68	26083	83	30201	97	33789	108	37065	110	45302	145
Depth 7.00 feet.	10	10718	64	13120	78.	15170	90	17001	101	18564	119	22713	135
	12	11811	65	14396	79.	16707	92	18709	103	20511	113	24988	137
	14	12936	66	15836	81.	18326	93	20462	104	22402	114	27479	140
	16	13965	66	17199	82.	19845	94	22155	105	24255	115	29799	142
	18	15142	67	18457	82.	21436	95	23878	106	26252	117	32144	143
	20	16231	68	19873	83	22919	96	25622	108	28155	118	34557	145
	25	19055	70	23286	85	26863	98	30030	100	32869	120	40376	148
	30	21817	71	26765	87	30984	100	34557	112	37884	123	46415	151
	35	24696	72	30184	88	34883	102	39033	114	42737	125	52444	153
	40	27631	73	33679	89	39085	103	43659	115	47703	126	58627	155
Depth 8.00 feet.	12	15388	69	18838	84	21683	96.8	24259	108	26611	119	32636	146
	15	17310	70	21303	86	24552	99.0	27404	110	29958	121	36803	148
	20	20736	72	25372	88	29289	102	32774	114	35884	125	44035	153
	25	24173	74	29618	90	34079	104	38244	116	41820	127	51233	156
	30	27526	75	33782	92	39008	106	43534	118	47729	130	58475	159
	35	30967	76	37903	93	43941	107	49123	120	53815	132	65973	162
	40	34496	77	42112	94	48518	108	54700	122	59852	133	73158	163
	45	37820	77	46457	95	53680	110	60121	123	65733	135	80528	165
	50	41500	78	50846	96	58660	111	65630	124	71913	136	87964	166
	60	48092	79	58854	97	68217	112	76243	125	83113	137	102326	168

DISCHARGE AND VELOCITIES

IN CUBIC AND LINEAL FEET PER MINUTE,

With Slopes of 3 to 1,

CHIEFLY FOR APPLICATION TO LARGE RIVERS.

(See Remarks in the *Rules for Use.*)

At the following Rates of Fall.

FALL.		2 inches per mile.		3 inches per mile.		4 inches per mile.		5 inches per mile.		6 inches per mile.	
Bottom widths. Feet.		Discharge in cubic feet.	Vel. feet.	Discharge in cubic feet.	Vel. feet.	Discharge in cubic feet.	Vel. feet.	Discharge in cubic feet.	Vel. feet.	Discharge in cubic feet.	Vel. feet.
Depth 8 feet.	40	37,553	75	47,308	92	54,774	107	60,928	119	66,560	130
	60	52,483	78	64,310	96	73,920	110	83,328	124	90,720	135
	80	66,310	80	81,452	98	104,016	113	104,832	126	114,816	138
	100	80,748	81	98,704	99	114,080	115	126,976	128	139,872	141
	120	95,040	83	115,200	100	133,632	116	149,760	130	164,736	143
	140	108,896	83	133,824	102	154,816	118	171,872	131	188,928	144
Depth 10 feet.	40	57,750	82	70,700	101	81,200	116	91,000	130	100,100	143
	60	77,220	86	94,500	105	108,900	121	121,500	135	133,200	148
	80	96,800	88	118,800	108	136,400	124	152,900	139	167,200	152
	100	115,830	89	141,700	109	163,800	126	183,300	141	200,200	154
	120	136,050	91	166,500	111	192,000	128	214,500	143	235,500	157
	140	155,210	91	190,400	112	221,000	130	246,500	145	270,300	159
Depth 12 feet.	60	105,753	92	130,176	113	149,760	130	167,040	145	183,168	159
	80	131,683	95	161,472	116	185,136	133	207,408	149	228,288	164
	100	156,182	96	190,944	117	220,320	135	246,432	151	269,280	165
	120	183,268	98	224,640	120	258,336	138	290,160	155	318,240	170
	140	209,088	99	255,552	121	295,680	140	331,584	157	364,264	172
	160	235,200	100	286,944	122	331,632	141	371,616	158	409,248	174
Depth 16 feet.	60	177,984	103	219,456	127	254,016	147	283,392	164	301,040	180
	80	219,136	107	266,240	130	309,248	151	346,112	169	378,880	185
	100	258,112	109	314,944	133	364,672	154	407,296	172	445,206	188
	120	295,680	110	362,880	135	422,016	157	470,500	175	513,408	191
	140	336,896	112	412,090	137	475,264	158	532,416	177	581,550	194
	160	376,064	113	459,264	138	532,480	160	595,712	179	652,288	196
Depth 20 feet.	100	380,800	119	467,200	146	540,800	169	601,600	188	662,400	207
	140	488,000	122	604,000	151	696,000	174	776,000	194	852,000	213
	180	600,000	125	739,200	154	850,600	177	950,400	198	1041,600	217
	220	711,200	127	873,600	156	1008,000	180	1131,200	202	1237,600	221
	260	825,600	129	1011,200	158	1164,800	182	1305,600	204	1427,200	223
	300	936,000	130	1144,800	159	1324,800	184	1490,400	207	1627,200	226
Depth 24 feet.	140	671,616	132	824,256	162	946,380	186	1063,392	209	1165,152	229
	180	816,480	135	1003,968	166	1155,168	191	1294,272	214	1421,280	235
	220	960,096	137	1177,344	168	1359,552	194	1520,736	217	1667,904	238
	260	1115,520	140	1362,528	171	1569,696	197	1752,960	220	1928,256	242
	300	1258,848	141	1544,544	173	1776,672	199	1990,944	223	2178,432	244
	340	1304,096	142	1720,512	174	1987,488	201	2224,800	225	2432,448	246
Depth 28 feet.	200	1153,040	145	1415,456	178	1638,112	206	1828,960	230	1964,144	247
	400	2073,456	153	2547,776	188	2940,784	217	3293,136	243	3604,832	266
	600	3006,864	157	3696,336	193	4251,744	222	4768,848	249	5228,496	273
	800	3935,568	159	4851,392	196	5593,952	226	6237,504	252	6831,552	276
	1000	4917,624	162	5979,344	197	6950,608	229	7739,760	255	8468,208	279
	1200	5824,224	162	7118,496	198	8233,008	229	9167,760	255	10066,560	280

TABLE OF DISCHARGE AND VELOCITIES,

IN CUBIC AND LINEAL FEET PER MINUTE,

For Culverts or Sewers of different diameters, *not full*, but carrying Water to two several Depths and Areas specified in each case.

The use of this Table may be extended by the following Rule:—

	Ft. ℔ Mile.		Ft. ℔ Mile.
For the Discharge and Velocity of a Culvert having a fall of	8	Take twice the Discharge & Velocity from the Columns of	2
	12		3
	16		4
	20		5
	24		6
	28		7
For the Discharge and Velocity of any Culvert having a fall of	½	Take half the Discharge & Velocity from the Columns of	2
	¾		3
	1		4
	1¼		5
	1½		6
	1¾		7

RATE OF FALL.			2 Feet ℔ Mile. 1 in 2640		3 Feet ℔ Mile. 1 in 1760		4 Feet ℔ Mile. 1 in 1320		5 Feet ℔ Mile. 1 in 1056		6 Feet ℔ Mile. 1 in 880		7 Feet ℔ Mile. 1 in 754.3	
Dia. of Cul.	QUANTITY RUNNING. Depth	Area.	Dis. per Min.	Vel. per Min.	Dis. per Min.	Vel. per Min.	Dis. per Min.	Vel. per Min.	Dis. per Min.	Vel. per Min.	Dis. per Min.	Vel. per Min.	Dis. per Min.	Vel. per Min.
Ft. In.	Ft. In.	Sq.Ft.	C. Ft.	Feet.	C. Ft.	Feet.	C. Ft.	Feet.	C. Ft.	Feet.	C. Ft.	Feet.	C. Ft.	Feet.
8.0	6.0	40.40	6,910	171.0	8,466	209.5	9,777	242.0	10,932	270.6	11,977	296.4	12,932	320.1
	4.0	25.13	3,911	155.6	4,782	190.3	5,529	220.0	6,178	245.8	6,772	269.5	7,312	290.9
7.0	5.3	30.93	4,933	159.5	6,056	195.8	6,990	226.0	7,825	253.0	8,557	276.6	9,254	299.2
	3.6	19.24	2,794	145.2	3,429	178.2	3,968	206.2	4,423	229.9	4,857	252.4	5,238	272.2
6.0	4.6	22.72	3,349	147.4	4,111	180.9	4,748	209.0	5,311	233.7	5,811	255.7	6,273	276.1
	3.0	14.13	1,904	134.7	2,331	165.0	2,689	190.3	3,008	212.8	3,303	233.7	3,559	251.9
5.0	3.9	15.78	2,135	135.3	2,612	165.5	3,020	191.4	3,376	213.9	3,697	234.3	3,992	253.0
	2.6	9.86	1,215	123.2	1,486	150.7	1,719	174.3	1,920	194.7	2,099	212.8	2,265	229.9
4.8	3.6	13.76	1,786	129.8	2,195	159.5	2,535	184.2	2,830	205.7	3,103	225.5	3,353	243.6
	2.4	8.52	1,007	118.2	1,237	145.2	1,429	167.7	1,598	187.5	1,748	205.1	1,888	221.6
4.3½	3.2½	11.51	1,431	124.3	1,754	152.3	2,026	176.0	2,266	196.9	2,482	215.6	2,678	232.6
	2.1½	7.14	809	113.3	990	138.6	1,143	160.0	1,280	179.3	1,402	196.3	1,512	211.7
4.0	3.0	10.10	1,222	121.0	1,494	147.9	1,728	171.0	1,933	191.4	2,116	209.5	2,289	226.6
	2.0	6.28	691	110.0	846	134.7	974	155.1	1,091	173.8	1,195	190.3	1,292	205.7
3.9	2.9½	8.87	1,039	117.1	1,268	143.0	1,468	165.5	1,639	184.8	1,795	202.4	1,942	218.9
	1.10½	5.52	589	106.7	723	130.9	832	150.7	932	168.8	1,020	184.8	1,098	199.0
3.4½	2.6½	7.17	793	110.5	970	135.3	1,120	156.2	1,254	174.9	1,372	191.4	1,481	206.8
	1.8½	4.47	447	100.1	548	122.6	634	141.9	708	158.4	777	173.8	838	187.5
3.0	2.3	5.68	594	104.5	725	127.6	837	147.4	937	165.0	1,028	180.9	1,109	195.2
	1.6	3.53	336	95.1	412	116.6	476	134.7	532	150.7	582	165.0	629	178.2
2.9	2.0¾	4.77	477	100.1	585	122.6	677	141.9	756	158.4	829	173.8	895	187.5
	1.4¾	2.97	271	91.3	332	111.6	384	129.2	430	144.6	470	158.4	508	171.0
2.5½	1.10½	3.82	361	94.6	443	116.0	511	133.6	571	149.6	626	163.9	677	177.1
	1.2¾	2.37	203	85.8	249	105.0	288	121.5	322	135.8	353	149.0	381	160.6
2.0	1.6	2.52	213	84.7	263	104.5	304	120.4	340	134.7	371	147.4	402	159.5
	1.0	1.57	122	77.5	149	95.1	173	110.0	193	123.2	212	134.7	228	145.2
1.6	1.1¼	1.41	104	73.7	127	90.2	147	104.5	164	116.6	180	127.6	195	138.0
	.9	0.88	59	66.5	72	81.9	83	94.6	93	105.6	102	116.0	110	124.8
1.0	.9	0.63	38	59.9	46	73.7	54	85.2	60	95.1	66	104.5	71	112.7
	.6	0.39	22	55.0	26	67.1	30	77.5	34	86.9	37	95.1	40	102.8

TABLE OF DISCHARGE AND VELOCITIES,

IN CUBIC AND LINEAL FEET PER MINUTE,

For different sized Culverts or Sewers of the Egg form, *not full*, but carrying Water to the several Depths and Areas specified in each case.

The use of this Table may be extended by the following Rule:—

	Ft. ℔ Mile.		Ft. ℔ Mile.		Ft. ℔ Mile.		Ft. ℔ Mile.
For the Discharge and Velocity of a Culvert having a fall of	8	Take twice the Discharge & Velocity from the Columns of	2	For the Discharge and Velocity of any Culvert having a fall of	¼	Take half the Discharge & Velocity from the Columns of	2
	12		3		½		3
	16		4		1		4
	20		5		1¼		5
	24		6		1½		6
	28		7		1¾		7

RATE OF FALL.				2 Feet ℔ Mile.		3 Feet ℔ Mile.		4 Feet ℔ Mile.		5 Feet ℔ Mile.		6 Feet ℔ Mile.		7 Feet ℔ Mile.	
Size of Culverts.			Quantity Running.	Dis. per Min.	Vel. per Min.	Dis. per Min.	Vel. per Min.	Dis. per Min.	Vel. per Min.	Dis. per Min.	Vel. per Min.	Dis. per Min.	Vel. per Min.	Dis. per Min.	Vel. per Min.
Ft. Ins. Vert.	Ft. Ins. Trans		Depth / Area	Ft. In.	Sq.Ft.	C Ft.	Feet.	C.Ft.	Feet.	C.Ft.	Feet.	C.Ft.	Feet.	C.Ft.	Feet.	C.Ft.	Feet.
6	3×3	9	4 6	13.37	1654	123.7	2029	151.8	2316	173.2	2417	195.8	2867	214.5	3095	231.5
			3 2	8.52	974	114.4	1194	140.2	1382	162.2	1546	181.5	1691	198.5	1827	214.5
5	10×3	6	4 3	11.75	1402	119.3	1719	146.3	1983	168.8	2215	188.6	2429	206.8	2623	223.3
			2 11	7.14	777	108.9	954	133.6	1103	154.5	1233	172.7	1350	189.2	1460	204.6
5	5×3	3	4 0	10.37	1197	115.5	1471	141.9	1699	163.9	1899	183.1	2076	200.2	2247	216.7
			2 8½	6.22	653	105.0	803	129.2	927	149.0	1036	166.6	1135	182.6	1224	196.9
4	7×2	9	3 5	7.51	805	107.2	987	131.4	1135	151.2	1272	169.4	1391	185.3	1503	200.2
			2 3½	4.48	436	97.3	534	119.3	618	138.0	692	154.5	756	168.8	818	182.6
3	9×2	3	2 9	4.93	474	96.2	580	117.7	672	136.4	751	152.3	824	167.2	889	180.4
			1 10½	2.98	255	85.5	313	105.0	362	121.5	404	135.5	442	148.5	478	160.6
3	4×2	0	2 6	4.01	364	90.7	445	111.1	514	128.1	573	143.0	628	156.7	679	169.4
			1 8	2.37	196	83.0	241	101.7	277	117.1	311	131.4	340	143.5	367	155.1
2	0×1	3	1 6	1.49	105	70.9	130	87.4	150	100.6	168	112.7	183	123.2	187	133.1
			1 0	0.87	52	59.9	64	73.7	74	85.2	82	95.1	90	103.9	98	112.7
1	4×0	10	1 0	0.66	38	58.3	47	70.9	54	81.9	61	91.8	66	100.6	72	108.9
			0 8	0.39	20	53.3	25	66.0	29	75.9	33	85.2	36	93.5	39	100.6

TABLE OF CONSTANTS,

FOR ASCERTAINING VELOCITIES,

APPLICABLE TO ANY FALL AND SECTION.

Hydraulic Mean Depths from .01 to 110.

Hydr. Mean Depth.	Tabular No. to be divided by $\sqrt{\frac{i}{h}}$	Hydr. Mean Depth.	Tabular No. to be divided by $\sqrt{\frac{i}{h}}$	Hydr. Mean Depth.	Tabular No. to be divided by $\sqrt{\frac{i}{h}}$	Hydr. Mean Depth.	Tabular No. to be divided by $\sqrt{\frac{i}{h}}$
.01	600	.51	4,285	1.10	6,293	6.10	14,819
.02	849	.52	4,327	1.20	6,572	6.20	14,940
.03	1,039	.53	4,368	1.30	6,841	6.30	15,060
.04	1,200	.54	4,409	1.40	7,099	6.40	15,179
.05	1,342	.55	4,450	1.50	7,346	6.50	15,297
.06	1,469	.56	4,490	1.60	7,589	6.60	15,414
.07	1,587	.57	4,529	1.70	7,823	6.70	15,530
.08	1,697	.58	4,569	1.80	8,050	6.80	15,646
.09	1,800	.59	4,608	1.90	8,270	6.90	15,761
.10	1,897	.60	4,647	2.00	8,485	7.00	15,874
.11	1,990	.61	4,686	2.10	8,695	7.10	15,988
.12	2,078	.62	4,724	2.20	8,899	7.20	16,100
.13	2,163	.63	4,762	2.30	9,100	7.30	16,211
.14	2,245	.64	4,800	2.40	9,295	7.40	16,322
.15	2,324	.65	4,837	2.50	9,487	7.50	16,432
.16	2,400	.66	4,874	2.60	9,674	7.60	16,541
.17	2,473	.67	4,911	2.70	9,859	7.70	16,649
.18	2,545	.68	4,947	2.80	10,040	7.80	16,757
.19	2.615	.69	4,983	2.90	10,217	7.90	16,864
.20	2,683	.70	5,019	3.00	10,392	8.00	16,970
.21	2,749	.71	5,055	3.10	10,564	8.10	17.076
.22	2,814	.72	5,091	3.20	10,733	8.20	17,181
.23	2,877	.73	5,126	3.30	10,900	8.30	17,286
.24	2,939	.74	5,161	3.40	11,063	8.40	17,390
.25	3,000	.75	5,196	3.50	11,225	8.50	17,493
.26	3,059	.76	5,231	3.60	11,384	8.60	17,596
.27	3,118	.77	5,265	3.70	11,541	8.70	17,698
.28	3,175	.78	5,299	3.80	11,696	8.80	17,799
.29	3,231	.79	5,333	3.90	11,849	8.90	17,900
.30	3,286	.80	5,366	4.00	12,000	9.00	18,000
.31	3,340	.81	5,400	4.10	12,149	9.10	18,100
.32	3,394	.82	5,433	4.20	12,296	9.20	18,199
.33	3,446	.83	5,466	4.30	12,442	9.30	18,298
.34	3,499	.84	5,499	4.40	12,586	9.40	18,395
.35	3,550	.85	5,531	4.50	12,728	9.50	18,493
.36	3,600	.86	5,564	4.60	12,868	9.60	18,590
.37	3,649	.87	5,596	4.70	13,007	9.70	18,687
.38	3,698	.88	5,629	4.80	13,145	9.80	18,783
.39	3,747	.89	5,660	4.90	13,282	9.90	18,878
.40	3,794	.90	5,692	5.00	13,416	10.00	18,974
.41	3,842	.91	5,723	5.10	13,550	20.00	26,832
.42	3,888	.92	5,755	5.20	13,682	30.00	32,862
.43	3,934	.93	5,786	5.30	13,813	40.00	37,944
.44	3,980	.94	5,817	5.40	13,943	50.00	42,426
.45	4,025	.95	5,848	5.50	14,071	60.00	46,470
.46	4,069	.96	5,879	5.60	14,198	70.00	50,196
.47	4,113	.97	5,909	5.70	14,324	80.00	53,664
.48	4,157	.98	5,939	5.80	14,450	90.00	56,922
.49	4,200	.99	5,970	5.90	14,574	100.00	60,000
.50	4,243	1.00	6,000	6.00	14,697	110.00	62,928

TABLE OF AREA, CIRCUMFERENCE, AND SQUARE ROOT OF THE FIFTH POWERS,

IN FEET AND DECIMALS,

For Diameters varying from $\frac{1}{4}$ inch to 12 feet,

TO FACILITATE CALCULATIONS BY HYDRAULIC FORMULÆ.

Diameter.	Area.	Circumference.	$\sqrt{D^5}$	Diameter.	Area.	Circumference.	$\sqrt{D^5}$	Diameter.	Area.	Circumference.	$\sqrt{D^5}$
Ft.in	Sq. feet.	Ft. Dec.	Ft. Dec.	Ft.in	Sq. feet.	Ft. Dec.	Ft. Dec.	Ft.in	Sq. feet.	Ft. Dec.	Ft. Dec.
0. $\frac{1}{4}$	.00034	.0653	.000062	1. 0	0.7854	3.142	1.000	3. 0	7.069	9.42	15.588
0. $\frac{5}{16}$	.00076	.0980	.000172	1. 1	0.9217	3.403	1.221	3. 1	7.467	9.69	16.693
0. $\frac{3}{8}$	.00136	.1307	.000354	1. 2	1.0690	3.665	1.470	3. 2	7.876	9.95	17.844
0. $\frac{7}{16}$	.00213	.1637	.000620	1. 3	1.2272	3.927	1.747	3. 3	8.296	10.21	19.042
0. $\frac{1}{2}$	.00307	.1963	.000975	1. 4	1.3962	4.189	2.053	3. 4	8.727	10.47	20.286
0. $\frac{9}{16}$	.00417	.2290	.001435	1. 5	1.5768	4.450	2.389	3. 5	9.168	10.73	21.577
0. 1	.0054	.2617	.002000	1. 6	1.7671	4.712	2.756	3. 6	9.621	10.99	22.918
0. 1$\frac{1}{8}$	.0085	.3272	.003498	1. 7	1.9690	4.974	3.155	3. 7	10.085	11.26	24.306
0. 1$\frac{3}{8}$	.0123	.3927	.005525	1. 8	2.1816	5.236	3.586	3. 8	10.559	11.52	25.742
0. 1$\frac{5}{8}$	.0167	.4584	.008127	1. 9	2.4053	5.498	4.051	3. 9	11.045	11.78	27.231
0. 2	.0218	.5236	.011329	1. 10	2.6398	5.759	4.551	3. 10	11.541	12.04	28.770
0. 2$\frac{1}{8}$	.0341	.654	.019809	1. 11	2.8852	6.021	5.086	3. 11	12.048	12.30	30.359
0. 3	.0491	.7854	.0312	2. 0	3.1416	6.283	5.657	4. 0	12.564	12.57	32.000
0. 3$\frac{1}{8}$	.0668	.9161	.0459	2. 1	3.4088	6.545	6.264	4. 3	14.186	13.35	37.237
0. 4	.0872	1.0471	.0641	2. 2	3.6870	6.806	6.909	4. 6	15.904	14.14	42.957
0. 4$\frac{1}{8}$	.1104	1.1781	.0827	2. 3	3.9761	7.068	7.593	4. 9	17.720	14.92	49.174
0. 5	.1363	1.3088	.1120	2. 4	4.2760	7.330	8.316	5. 0	19.635	15.71	55.901
0. 5$\frac{1}{8}$	.1650	1.4401	.1428	2. 5	4.5873	7.591	9.079	5. 6	23.758	17.28	70.942
0. 6	.1963	1.5708	.1768	2. 6	4.9087	7.854	9.882	6. 0	28.274	18.85	88.181
0. 7	.2672	1.8325	.2599	2. 7	5.2480	8.116	10.726	6. 6	33.183	20.42	107.717
0. 8	.3490	2.0942	.3629	2. 8	5.5850	8.378	11.612	7. 0	38.485	21.99	129.642
0. 9	.4418	2.3562	.4871	2. 9	5.9396	8.639	12.541	7. 6	44.179	23.56	154.047
0. 10	.5454	2.6180	.6339	2. 10	6.3053	8.901	13.512	8. 0	50.266	25.13	181.019
0. 11	.6600	2.8797	.8043	2. 11	6.6813	9.163	14.528	8. 6	56.745	26.70	210.643
9. 0	63.617	28.27	243.00	10.0	78.54	31.41	316.23	11.0	95.03	34.55	401. 31
9. 6	70.882	29.84	278.17	10.6	86.59	32.98	357.26	12.0	113.10	37.70	498. 83

TABLE OF CONSTANTS

FOR ASCERTAINING DISCHARGE, &c.,

APPLICABLE TO ANY LENGTH AND PRESSURE.

Diameters of Pipes ¼ inch to 4 feet.

RULE.—When the length, pressure and diameter are given, to find the discharge; *Divide the Tabular No. opposite the given diameter, by the square root of the specific gravity of the gas (air = 1.00) multiplied by the rate of inclination (length ÷ pressure)*; the result is the discharge in cubic feet per minute.

When the length, pressure and discharge are given, to find the diameter; *Multiply the discharge by the* $\sqrt{}$*sp. gr.* × *rate of inclination (as above); opposite the nearest corresponding number to the result in the table,* is the required diameter.

When the length, diameter and discharge are given, to find the pressure; *Multiply the length by the sp. gr. and divide the result by the square of (Tabular No.* ÷ *discharge)*; the quotient is the pressure.

NOTE.—Lengths to be taken in feet; pressure in *inches of water*; discharge in cubic feet per minute.

Diameter.		Tabular No. to be divided by $\sqrt{s\frac{l}{p}}$	Diameter.		Tabular No. to be divided by $\sqrt{s\frac{l}{p}}$	Diameter.		Tabular No. to be divided by $\sqrt{s\frac{}{p}}$
Ft.	In.		Ft.	In.		Ft.	In.	
0	0¼	1.2028	0	7	5,041.28	2	1	121,531
0	0⅜	3.3368	0	8	7,039.60	2	2	134,040
0	0½	6.8676	0	9	9,450.22	2	3	147,314
0	0⅝	12.0280	0	10	12,297.5	2	4	161,337
0	0¾	18.9150	0	11	15,603.7	2	5	176,126
0	0⅞	27.8390	1	0	19,400.0	2	6	191,711
0	1	38.8000	1	1	23,682.9	2	7	208,087
0	1¼	67.8612	1	2	28,516.4	2	8	225,272
0	1½	107.185	1	3	33,889.4	2	9	243,297
0	1¾	157.664	1	4	39,820.7	2	10	262,139
0	2	219.783	1	5	46,337.5	2	11	281,841
0	2½	384.295	1	6	53,459.6	3	0	302,413
0	3	605.765	1	7	61,198.6	3	2	346,176
0	3½	890.984	1	8	69,568.8	3	4	393,544
0	4	1244.06	1	9	78,597.6	3	6	444,602
0	4½	1604.13	1	10	88,285.5	3	8	499,397
0	5	2173.27	1	11	98,662.5	3	10	558,132
0	6	3429.47	2	0	109,741.9	4	0	620,800

EXAMPLE.—Required the discharge of a pipe 6 inches diameter and 4000 feet long under a pressure of .5 or half an inch head of water—the specific gravity of the gas being .420 (air = 1.000).

Tabular No. for 6 inches $\frac{3429.47}{\sqrt{.42\frac{4000}{.5}}} = \frac{3429.47}{57.96} = 59.16$ Cubic feet per minute.

TABLE OF CONSTANTS,

FOR ASCERTAINING DISCHARGE, &c.,

APPLICABLE TO ANY LENGTH AND HEAD.

Diameter of Pipes 1 inch to 10 feet.

RULE FOR DISCHARGE.—When the length, fall, and diameter are given, *divide the tabular number opposite the diameter by the square root of the rate of inclination*; the result will be the discharge in cubic feet per minute.

RULE FOR DIAMETER.—When the length, fall, and discharge are given, *multiply the discharge by the square root of the rate of inclination; find the nearest corresponding number in the table*, and opposite to it is the required diameter.

RULE FOR HEAD.—When the length, discharge and diameter of pipes are given, *divide the tabular number for the given diameter by the discharge; square the result, and divide by it the length of pipe*; the quotient is the head required for driving the given quantity of water through the pipe.

Note.—All terms are to be taken *in lineal* or *cubic feet per minute* respectively.

Diameter.		Tabular No. to be divided by $\sqrt{\frac{l}{h}}$	Diameter.		Tabular No. to be divided by $\sqrt{\frac{l}{h}}$	Diameter.		Tabular No. to be divided by $\sqrt{\frac{l}{h}}$
Ft.	In.		Ft.	In.		Ft.	In.	
0	1	4.71	1	7	7,433	3	7	57,265
0	1½	8.48	1	8	8,449	3	8	60,648
0	1½	13.02	1	9	9,544	3	9	64,156
0	1¾	19.15	1	10	10,722	3	10	67,782
0	2	26.69	1	11	11,983	3	11	71,526
0	2½	46.67	2	0	13,328	4	0	75,392
0	3	73.50	2	1	14,758	4	1	79,380
0	3½	108.14	2	2	16,278	4	2	83,492
0	4	151.02	2	3	17,889	4	3	87,730
0	4½	194.84	2	4	19,592	4	6	101,207
0	5	263.87	2	5	21,390	4	9	115,854
0	6	416.54	2	6	23,282	5	0	131,703
0	7	612.32	2	7	25,270	5	3	148,791
0	8	854.99	2	8	27,358	5	6	167,139
0	9	1,147.61	2	9	29,547	5	9	186,786
0	10	1,493.47	2	10	31,834	6	0	207,754
0	11	1,894.93	2	11	34,228	6	6	253,781
1	0	2,356.00	3	0	36,725	7	0	305,437
1	1	2,876.68	3	1	39,329	7	6	362,935
1	2	3,463.32	3	2	42,040	8	0	426,481
1	3	4,115.93	3	3	44,863	8	6	496,275
1	4	4,836.87	3	4	47,794	9	0	572,508
1	5	5,628.48	3	5	50,835	9	6	655,369
1	6	6,493.14	3	6	53,995	10	0	745,038

EXAMPLE.—Required the discharge of a pipe 6 inches diameter and 2,000 feet long, with 20 feet fall:—

$\frac{2,000}{20}$ = fall 1 in 100, then $\sqrt{100}=10$

and Tabular Number $\frac{416.5}{10}$ = 41.65 cubic feet per minute.

Note.—If half the tabular numbers be taken, the discharge will be nearly that for pipes half full; and the table is thus applicable to sewers, drains, &c.

TABLE OF DISCHARGE AND VELOCITIES,

IN CUBIC AND LINEAL FEET PER MINUTE.

FOR PIPES RUNNING FULL WITH A CONSTANT HEAD.

Diameters from 3 to 60 Inches,

With Rates of Fall extending from 5 feet to 35 feet per Mile.

FALL.	5 Feet ℔ Mile.		10 Feet ℔ Mile.		15 Feet ℔ Mile.		20 Feet ℔ Mile.		25 Feet ℔ Mile.		30 Feet ℔ Mile.		35 Feet ℔ Mile.	
RATE.	1 in 1056.		1 in 528.		1 in 352.		1 in 264.		1 in 211.2		1 in 176.0		1 in 150.86	
Diam. of Pipes.	Disch. per Min.	Vel per Min.	Disch. per Min.	Vel. per Min.	Disch. per Min.	Vel. per Min.	Disch. per Min.	Vel. per Min.	Disch. per Min.	Vel. per Min.	Disch. per Min.	Vel. per Min.	Disch. per Min.	Vel. per Min.
INCHES.	C Feet	Feet.	C Feet	Feet.	C Feet	Feet	C Feet	Feet.	C Feet	Feet.	C Feet	Feet.	C Feet	Feet.
3	2.26	45.3	3.2	64.0	3.9	78.4	4.5	90.4	5.06	101.2	5.55	111.0	6.0	119.8
6	12.8	65.4	18.1	92.4	22.2	113.3	25.6	130.7	28.6	146.1	31.4	160.0	33.9	172.9
9	35.3	79.9	49.9	113.0	61.1	138.3	70.6	159.5	79.0	178.4	86.5	195.6	93.4	211.1
12	72.5	92.5	102.5	130.6	126	159.5	155	196.7	162	205.9	178	225.5	192	243.6
15	127	103.8	179	146.8	219	179.8	253	207.5	283	231.9	310	254.4	335	274.6
18	200	113.5	282	160.3	346	196.5	399	226.8	447	253.7	489	278.0	528	300.4
21	294	122.4	415	173.0	509	211.2	587	244.1	657	273.1	720	299.3	777	323.2
24	410	130.6	580	184.7	710	226.2	820	261.0	917	292.0	1,005	319.7	1,085	345.5
27	550	138.6	778	196.0	953	240.1	1,100	277.1	1,230	309.9	1,348	339.5	1,456	366.5
30	716	146.2	1,013	206.8	1,241	253.1	1,432	292.2	1,602	326.8	1,755	358.1	1,895	386.6
33	909	153.3	1,286	216.8	1,575	265.5	1,817	306.3	2,033	342.7	2,228	375.6	2,405	405.5
36	1,130	160.1	1,598	226.3	1,957	277.3	2,259	319.9	2,527	357.8	2,769	392.2	2,989	423.4
39	1,380	166.5	1,952	235.4	2,391	288.4	2,759	332.8	3,086	372.3	3,383	408.7	3,652	440.4
42	1,661	172.7	2,350	244.2	2,878	299.2	3,321	345.3	3,715	386.3	4,071	423.4	4,395	457.1
45	1,974	178.8	2,791	252.8	3,419	309.7	3,945	357.3	4,413	399.8	4,836	437.2	5,221	473.0
48	2,320	184.7	3,281	261.2	4,018	319.9	4,637	369.1	5,187	412.9	5,684	452.5	6,137	488.5
51	2,699	190.3	3,817	269.2	4,675	329.7	5,394	380.3	6,035	425.5	6,614	466.3	7,140	503.4
54	3,110	195.6	4,403	276.9	5,393	339.2	6,223	391.4	6,959	437.7	7,630	479.9	8,237	518.1
57	3,564	201.1	5,041	284.5	6,174	348.4	7,124	401.9	7,967	449.6	8,735	492.7	9,430	531.9
60	4,052	206.4	5,731	291.9	7,020	357.6	8,100	412.6	9,058	461.4	9,930	505.8	10720	546.1

TABLE OF DISCHARGE AND REQUIRED HEAD

FOR PIPES RUNNING FULL AT STATED VELOCITIES.

Diameters from 1 Inch to 72 Inches.

Velocities.	180 Feet per Min.			200 Feet per Min.			220 Feet per Min.		
Diam. of Pipes.	Head required per 100 Feet.	Discharge.		Head required per 100 Feet.	Discharge.		Head required per 100 feet.	Discharge.	
		Cubic Feet per Min.	Thousands of Gallons per Day.		Cubic Feet per Min.	Thousands of Gallons per Day.		Cubic Feet per Min.	Thousands of Gallons per Day.
Inches.	Feet.			Feet.			Feet.		
1	4.32	.98	8.8	5.33	1.09	9.8	6.45	1.20	10.8
2	2.16	3.92	35.3	2.67	4.36	39.2	3.22	4.80	43.2
3	1.44	8.84	79.6	1.78	9.82	88.4	2.15	10.80	97.2
4	1.08	15.70	141.3	1.33	17.44	157.0	1.61	19.18	172.6
5	0.86	24.53	220.8	1.07	27.26	245.3	1.29	29.99	269.9
6	0.72	35.33	318.0	0.89	39.26	353.3	1.08	43.19	388.7
7	.62	48.10	432.9	0.76	53.44	481.0	0.92	58.78	529.0
8	.54	62.82	565.1	0.67	69.80	628.2	0.81	76.78	691.0
9	.48	79.52	715.7	0.59	88.36	795.2	0.72	97.20	874.8
10	.43	98.17	883.5	0.53	109.08	981.7	0.64	119.99	1,079.9
11	.39	118.8	1,069.2	0.49	132.0	1,188.0	0.59	145.2	1,306.8
12	.36	141.4	1,272.6	0.45	157.1	1,413.9	0.54	172.8	1,555.2
13	.33	165.9	1,493.1	0.41	184.3	1,658.7	0.50	202.8	1,825.2
14	.31	192.4	1,731.6	0.38	213.8	1,924.2	0.46	235.2	2,116.8
15	.29	220.9	1,988.1	0.36	245.4	2,208.6	0.43	270.0	2,430.0
16	.27	251.3	2,261.7	0.33	279.2	2,512.8	0.40	307.2	2,764.8
17	.26	283.8	2,554.2	0.31	315.3	2,837.7	0.38	346.9	3,122.1
18	.24	318.1	2,862.9	0.30	353.4	3,180.6	0.36	388.8	3,499.2
20	.22	392.7	3,534.3	0.27	436.3	3,926.7	0.32	479.9	4,319.1
22	.20	475.2	4,276.8	0.24	528.0	4,752.0	0.29	580.7	5,226.3
24	.18	565.5	5,089.5	0.22	628.3	5,654.7	0.27	691.1	6,219.9
27	.16	715.7	6,441.3	0.20	795.2	7,156.8	0.24	874.7	7,872.3
30	.14	883.8	7,954.2	0.18	981.7	8,835.3	0.21	1,079.9	9,719.1
32	.13	1,005.3	9,047.7	0.17	1,117.0	10,053.	0.20	1,228.7	11,058.
34	.13	1,134.9	10,214.	0.16	1,261.1	11,349.	0.19	1,387.2	12,484.
36	.12	1,272.4	11,451.	0.15	1,413.8	12,724.	0.18	1,555.2	13,996.
39	.11	1,493.3	13,439.	0.14	1,699.2	14,932.	0.17	1,825.1	16,425.
42	.10	1,731.8	15,586.	0.13	1,924.2	17,317.	0.15	2,116.6	19,049.
45	.10	1,988.1	17,892.	0.12	2,209.0	19,881.	0.14	2,429.9	21,869.
48	.09	2,261.5	20,353.	0.11	2,512.8	22,615.	0.14	2,764.1	25,056.
51	.09	2,543.8	22,894.	0.10	2,837.2	25,535.	0.13	3,120.9	28,088.
54	.08	2,862.7	25,764.	0.10	3,180.8	28,627.	0.12	3,498.9	31,490.
60	.07	3,534.3	31,809.	0.09	3,927.0	35,343.	0.11	4,319.7	38,877.
66	.07	4,276.4	38,488.	0.08	4,751.6	42.764.	0.10	5,226.8	47,041.
72	.06	5,289.3	47,604.	0.08	5,654.8	50,893.	0.09	6,220.3	55,982.

FRICTION OF BENDS.—TABLE 9.

THEORETIC HEAD IN INCHES

Required to overcome resistance of Bends from 10° to 90°

FOR PIPES, CULVERTS, DRAINS, AND RIVERS,

With Currents having the mean velocities stated in the first column.

NOTE.—The numbers give the height in inches or decimals required to drive water past the specified bends, varying according to the velocity of discharge.

Examples.—A pipe carrying water at a mean velocity of 300 feet per minute
has 3 bends of 20 degrees each .126 × 3 = .378
and 7 bends of 50 degrees each .632 × 7 = 4.424
and 20 bends of 40 degrees each .446 × 20 = 8.920

Total head required 13.722 inches.

A River having a mean velocity of 110 feet per minute
has 5 bends of 45 degrees each = .072 × 5 = .360
and 3 bends of 70 degrees each = .128 × 3 = .384
and 2 bends of 90 degrees each = .144 × 2 = .288

Total additional fall required 1.032 inch.

Mean Velocity of Current.	Angles of Bend with forward line of direction.									
	10°	20°	30°	40°	45°	50°	60°	70°	80°	90°
Feet per Minute.	Ins. of Head.	Ins of Head.	Ins. of Head.	Ins. of Head.	Ins. of Head.	Ins. of Head.	Ins. of Head.	Ins. of Head.	Ins. of Head.	Ins. of Head.
15	.00008	.0003	.0006	.0011	.0013	.0016	.0020	.0024	.0026	.0027
20	.00014	.0005	.0012	.0020	.0024	.0028	.0036	.0042	.0046	.0048
25	.00022	.0009	.0018	.0031	.0037	.0044	.0056	.0066	.0072	.0075
30	.0003	.0012	.0027	.0044	.0054	.0063	.0081	.0095	.0104	.0108
35	.0004	.0017	.0036	.0060	.0073	.0086	.0110	.0129	.0142	.0147
40	.0006	.0022	.0048	.008	.0096	.012	.014	.016	.018	.019
45	.0007	.0028	.0060	.010	.012	.014	.018	.021	.023	.024
50	.0009	.0035	.0075	.012	.015	.017	.022	.026	.029	.030
55	.0011	.004	.009	.015	.018	.021	.027	.032	.035	.036
60	.0013	.005	.011	.018	.021	.025	.032	.038	.042	.043
65	.0015	.006	.012	.021	.025	.029	.037	.045	.049	.050
70	.0017	.007	.015	.024	.029	.034	.044	.052	.057	.059
75	.0020	.008	.017	.028	.033	.039	.050	.060	.065	.067
80	.0023	.009	.019	.031	.038	.042	.057	.068	.074	.077
85	.0026	.010	.022	.036	.043	.051	.064	.076	.084	.087
90	.0029	.011	.024	.040	.048	.057	.072	.086	.094	.097
95	.0032	.012	.027	.045	.054	.063	.081	.095	.105	.108
100	.0036	.014	.030	.049	.060	.070	.090	.106	.116	.120
105	.0039	.015	.033	.054	.066	.077	.099	.117	.128	.134
110	.0043	.017	.036	.060	.072	.085	.108	.128	.140	.144
120	.0052	.020	.043	.071	.086	.101	.129	.152	.167	.173
130	.0061	.023	.050	.083	.101	.119	.151	.179	.196	.202
140	.0070	.027	.059	.097	.117	.138	.176	.207	.228	.235
150	.0081	.031	.067	.111	.135	.158	.202	.238	.261	.270
175	.0111	.043	.092	.153	.185	.217	.277	.327	.357	.370
200	.014	.056	.120	.198	.240	.281	.360	.424	.405	.480
250	.022	.087	.187	.309	.375	.439	.562	.662	.726	.750
300	.032	.126	.270	.446	.540	.632	.810	.953	1.046	1.080
350	.044	.172	.367	.607	.735	.867	1.102	1.298	1.424	1.470
400	.057	.224	.480	.793	.960	1.125	1.440	1.695	1.860	1.920

TABLE OF APPROXIMATE RISE OF WATER,

OCCASIONED BY BRIDGES, WEIRS, &c.,

From Gregory's "Mathematics for Practical Men."

Note.—This table is approximative only, because the velocity must be an ever varying quantity, fluctuating at all times with the amount of river flood, and also greatly depending on the state of river section above and below bridge. The table was taken by Dr. Olinthus Gregory, from Du Buat's theorems.

Vel. of Stream	Probable Rise of Water, For Obstructions from one-tenth to six-tenths; the whole section of the River being taken as unity. OBSTRUCTION.					
	.10	.20	.30	.40	.50	.60
Feet per Min.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
180	.05	.12	.21	.36	.61	1.07
240	.08	.18	.34	.58	.97	1.70
300	.12	.28	.52	.88	1.49	2.60
360	.16	.37	.69	1.18	1.99	3.49
480	.27	.64	1.19	2.03	3.42	5.99
600	.42	.99	1.83	3.12	5.27	9.22

SMEATON'S TABLE OF THE HEAD

FOR DRIVING WATER THROUGH 100 FEET LINEAL OF PIPES,

From 1 to 12 inches diameter, at Velocities increasing from 90 to 270 feet per minute, with the relative discharge in cubic feet per minute, compiled from Smeaton's Papers.

Diam of Pipes	Assumed Velocities of Water through Pipes in Feet per Minute.													
	90		120		150		180		210		240		270	
	Dis	Head.	Dis.	Head.	Dis.	Head	Dis.	Head.	Dis.	Head	Dis.	Head.	Dis.	Head.
Inches.	C. Ft. per M.	Feet.	C. Ft. per M.	Feet.	C. Ft. per M	Feet.	C. Ft per M.	Feet.	C. Ft per M.	Feet	C. Ft. per M.	Feet.	C. Ft. per M.	Feet.
1	.45	1.46	.60	2.40	.76	3.58	.92	5.04	1.08	6.83	1.23	8.92	1.39	11.30
1.5	1.01	0.97	1.36	1.60	1.69	2.38	2.03	3.36	2.36	4.56	2.92	5.94	3.05	7.52
2	1.81	0.74	2.41	1.20	3.01	1.80	3.62	2.52	4.22	3.42	4.82	4.46	5.43	5.63
3	4.41	0.42	5.88	0.80	7.35	1.20	8.82	1.68	10.3	2.28	11.7	2.97	13.2	3.76
4	7.69	0.37	10.26	0.60	12.82	0.90	15.39	1.26	17.9	1.72	20.5	2.23	23.1	2.81
6	17.7	0.24	23.5	0.40	29.4	0.60	35.2	0.84	41.2	1.14	47.0	1.48	53.0	1.87
9	39.8	0.156	53.04	0.27	66.3	0.40	79.6	0.56	92.8	0.76	106	0.99	119	1.25
12	70.7	0.12	94.2	0.20	118	0.31	141	0.42	165	0.57	188	0.74	212	0.94

This Table will be found to be somewhat similar in its results to Table 5, but is not of so extensive an application, and gives too low a discharge on the larger class of pipes.

EXAMPLE.—.42 feet is the head per 100 feet to drive 141 cubic feet, at a velocity of 180 feet per minute, through a 12-inch pipe.

TABLE OF THE RESISTANCE TO ONE SQUARE FOOT,

Moving through Water (or vice versâ),

At Velocities from 60 to 900 Feet per Minute,

And at angles with the line of force from 6 to 90 Degrees.

Note.—This table gives the *theoretical* resistance due to the several velocities, and is computed by the formula $.975 \times \sqrt{\text{vel. in feet per second}} =$ resistance at right angles per square foot, in lbs. The angular resistances are computed from the same formula as Hutton's Experiments, as explained at the head of Table 10a Resistance for variable figures appears to be almost beyond any assigned rule; for the best information see Beaufoy's Experiments. Resistance under circumstances of compound motion should be at its maximum, according to the known effects of water-wheels, when the surface moves at from one-half to two-thirds of the velocity of the fluid, when the best applications produce 75 per cent. of the weight; although at high velocities only 30 per cent. is produced.

Angle of Surface, with Line of Resistance.	Pressure per Square Foot for the following Velocities per Minute.							
	60 Feet.	120 Feet.	180 Feet.	240 Feet.	300 Feet.	480 Feet.	600 Feet.	900 Feet.
Degrees	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
6	.022	.090	.202	.359	.561	1.435	2.242	5.046
7	.027	.109	.246	.437	.682	1.747	2.730	6.142
8	.033	.133	.298	.530	.829	2.122	3.315	7.459
9	.039	.156	.351	.624	.975	2.496	3.900	8.775
10	.045	.179	.404	.718	1.121	2.870	4.485	10.091
15	.089	.355	.798	1.420	2.218	5.678	8.872	19.963
20	.152	.608	1.369	2.434	3.802	9.734	15.210	34.222
25	.235	.940	2.115	3.760	5.874	15.038	23.497	52.869
30	.338	1.353	3.045	5.413	8.458	21.653	33.832	76.123
35	.449	1.798	4.045	7.192	11.237	28.766	44.947	101.132
40	.565	2.258	5.081	9.032	14.113	36.130	56.452	127.018
45	.665	2.660	5.985	10.639	16.624	42.557	66.495	149.614
50	.749	2.995	6.739	11.981	18.720	47.923	74.880	168.480
55	.812	3.249	7.310	12.995	20.304	51.979	81.217	182.739
60	.864	3.455	7.775	13.822	21.596	55.286	86.385	194.366
65	.902	3.607	8.117	14.430	22.547	57.720	90.187	202.922
70	.932	3.728	8.389	14.914	23.302	59.654	93.210	209.722
75	.953	3.810	8.573	15.241	23.814	60.965	95.257	214.329
80	.966	3.857	8.678	15.428	24.107	61.714	96.427	216.026
85	.973	3.892	8.757	15.569	24.326	62.275	97.305	218.936
90	.975	3.900	8.775	15.600	24.375	62.400	97.500	219.375

TABLE OF THE RESISTANCE TO ONE SQUARE FOOT,

Moving through Air (or vice versâ),

At Velocities from 720 to 3,600 Feet per Minute,

And at angles with the line of force from 6 Degrees to 90 Degrees, or Right Angles.

From Hutton's Experiments.

Note.—Dr. Hutton found that the resistance varied as the square of the velocity nearly, and to an inclined surface, as the 1.84 power of the sine × cosine. This table is constructed thus:—.841 *s* 1.84 *c* = resistance in ounces to a plate 32 square inches, moving at the rate of 12 feet per second. Mr. Hutton's experiments went to show that the figure of a plane makes no sensible difference in the resistance, but that a convex surface of a hemisphere with a surface double the base, had only half the resistance, and a cone with 74 inches area, at an angle of 25. 42, suffers far less resistance than a plane of equal angle, with 32 inches area; the areas being as 74 to 32, and the resistance as 37 to 25. It must be observed that at high velocities, railway and fast canal boat experiments shew that resistance becomes nearly a constant quantity.

Angle of Surface, with Line of Resistance.	Pressure per Square Foot for the following Velocities per Minute.						
	720 Feet.	1,080 Feet.	1,440 Feet.	1,800 Feet.	2,400 Feet.	3,000 Feet.	3,600 Feet.
Degrees	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
6	.0054	.0121	.0216	.0337	.060	.094	.135
7	.0066	.0148	.0264	.0412	.074	.115	.165
8	.0080	.0180	.0320	.0500	.089	.139	.200
9	.0094	.0211	.0376	.0587	.105	.163	.235
10	.0109	.0245	.0436	.0680	.121	.189	.272
15	.0215	.0484	.0860	.1344	.239	.373	.537
20	.0368	.0828	.1472	.2300	.409	.639	.920
25	.0569	.1280	.2276	.3556	.632	.988	1.422
30	.0820	.1845	.3280	.5325	.911	1.423	2.050
35	.1089	.2450	.4356	.6806	1.210	1.890	2.722
40	.1368	.3078	.5472	.8550	1.520	2.375	3.420
45	.1611	.3625	.6444	1.0069	1.790	2.797	4.027
50	.1814	.4081	.7256	1.1337	2.015	3.149	4.535
55	.1968	.4428	.7872	1.2300	2.186	3.416	4.920
60	.2093	.4709	.8372	1.3081	2.325	3.633	5.232
65	.2185	.4916	.8740	1.3656	2.427	3.793	5.462
70	.2258	.5080	.9032	1.4112	2.509	3.920	5.645
75	.2308	.5193	.9232	1.4415	2.564	4.007	5.770
80	.2336	.5256	.9344	1.4600	2.596	4.055	5.840
85	.2358	.5305	.9432	1.4737	2.620	4.093	5.895
90	.2362	.5314	.9448	1.4762	2.624	4.100	5.905

EXPANSION OF WATER, STEAM AND GAS.—TABLE 11.

DENSITY AND VOLUME OF WATER.

At Temperatures varying from 32° to 100° Fahrenheit, taking maximum density and volume (at 39°.4) as unity.

Authorities:—*Hallström*, "*Ann. Ch. et Ph. XXVIII., p. 90.*" *Péclet*, "*Traité de la Chaleur.*"

Temp. Degrs.	Density and Volume at 39°.4=1.00.		Temp. Degrs.	Density and Volume at 39°. 4=1.00.		Temp. Degrs.	Density and Volume at 39°. 4=1.00	
Fahr.	Density.	Volume.	Fahr.	Density.	Volume.	Fahr.	Density.	Volume.
32 0	.999892	1.000108	51.8	.999703	1.000297	73.4	.99783	1.00217
33 8	.999918	1.000052	53.6	.999612	1.00039	75.2	.99760	1.00240
35 6	.999972	1.000028	55.4	.999508	1.00049	77.0	.99736	1.00264
37 4	.999992	1.000008	59 0	.999226	1.00074	78.8	.99711	1.00290
39 4	**1.00000**	**1.00000**	**60 8**	**.99913**	**1.00087**	**80.6**	**.99684**	**1.00317**
41 0	.999995	1.000005	62.6	.99897	1.00102	82.4	.99657	1.00344
42 8	.999977	1 000023	64.4	.99881	1.00119	84.2	.99629	1.00373
46 4	.999904	1 000095	66.2	.99864	1.00136	86.0	.99599	1.00402
48.2	.999850	1.000150	69.8	.99826	1.00176	90.0	.99566	1.00434
50.0	**.999782**	**1.000220**	**71.6**	**.99805**	**1.00195**	**212.0**	**.95566**	**1.04640**

TEMPERATURE AND VOLUME OF STEAM.

WITH CORRESPONDING PRESSURES.

Authorities:—*Regnault, Tredgold and De Pambour.*

Temp. Deg. Fah.	Volumes of Steam from one of Water.	Pressure.			Temp. Deg. Fahr.	Volumes of Steam from one of Water.	Pressure.		
		lbs. per sq. in.	Inches of Mercury.	Atmosphr.			lbs. per sq. in.	Inches of Mercury.	Atmosphr.
103	20,954	1	2.04	0.07	268	677	40	81.60	2.72
126	10,907	2	4.08	0.14	271	647	42	85.68	2.85
141	7,455	3	6.12	0.20	274	620	44	89.76	2.99
152	5,695	4	8.16	0.27	276	608	45	91.80	3.06
161	**4.624**	**5**	**10.20**	**0.34**	**282**	**552**	**50**	**102.0**	**3.40**
169	3,901	6	12.24	0.41	288	506	55	112.2	3.74
176	3,380	7	14.28	0.47	294	467	60	122.4	4.08
182	2,985	8	16.32	0.54	299	434	65	132.6	4.42
187	2,676	9	18.36	0.61	304	406	70	142.8	4.76
192	**2.427**	**10**	**20.40**	**0.68**	**309**	**381**	**75**	**153.0**	**5.10**
201	2,050	12	22.44	0.75	313	359	80	163.2	5.44
209	1,777	14	28.56	0.95	318	340	85	173.4	5.78
212	1,700	14.7	30.00	1.00	322	323	90	183.6	6.12
216	1,572	16	32.64	1.09	325	307	95	193.8	6.46
222	**1.410**	**18**	**36.72**	**1.22**	**329**	**293**	**100**	**204.0**	**6.80**
228	1,280	20	40.80	1.36	337	269	110	224.4	7.48
233	1,172	22	44.88	1.50	343	249	120	244.3	8.16
238	1,082	24	48.96	1.63	349	231	130	265.2	8.84
243	1,005	26	53.04	1.77	355	216	140	285.6	9.52
247	**939**	**28**	**57.12**	**1.90**	**361**	**203**	**150**	**306.0**	**10.20**
251	882	30	61.20	2.04	366	193	160	326.4	10.88
255	831	32	65.28	2.18	371	183	170	346.8	11.56
258	786	34	69.36	2.31	375	173	180	367.2	12.24
262	746	36	73.44	2.45	380	163	190	387.6	12.92
265	**710**	**38**	**77.52**	**2.58**	**384**	**153**	**200**	**408.0**	**13.60**

TEMPERATURE AND VOLUME OF AIR AND GAS.

Brande's Manual of Chemistry; Thomson.

Temp. Fah.	Bulk.	Temp. Fah.	Volume.	Temp. Fah.	Volume.	Temp. Fah.	Volume.	Temp. Fah.	Volume.
−33	0.86500	52	1.04166	72	1.08320	92	1.12480	170	1.28704
32	1.00000	54	1.04576	74	1.08736	94	1.12899	180	1.30784
34	1.00416	56	1.04992	76	1.09152	96	1.13312	190	1.32864
36	1.00833	58	1.05408	78	1.09568	98	1.13728	200	1.34944
38	**1 01248**	**60**	**1.05824**	**80**	**1.09984**	**100**	**1.14144**	**210**	**1.37024**
40	1.01666	62	1 06240	82	1.10400	110	1.16224	212	1.37440
42	1.02080	64	1.06656	84	1.10816	120	1.18304	302	1.55760
44	1.02496	66	1.07072	86	1.11232	130	1.20384	392	1.73890
46	1.02916	68	1.07488	88	1.11648	140	1.22464	482	1.91890
48	1.03333	70	1.07904	90	1.12064	150	1.24544	572	2.09760
50	**1.03749**	**71**	**1.08112**	**91**	**1.12272**	**160**	**1.26624**	**680**	**2.31250**

VALUE OF WATER POWER.—TABLE 12.

TABLE OF NOMINAL HORSE POWER,

FOR ONE FOOT OF FALL,

With the different Effective Values as applied to Undershot Breast and Overshot Wheels and to the Turbine.

Rule.—Add together the numbers, from the column applicable to the case, opposite the several amounts of cubic feet making up the estimated run of the streams, and multiply the sums by the number of feet of fall; the result is the H. power of the Mill.

Note.—An ordinary Mill will grind about 1 bushel per horse power per hour—a very good one 1.2 bushels—therefore multiply the tabular numbers by 1 or 1.2 (according to the case), and by the number of hours worked, for the bushels ground per diem.

Discharge of Stream per Minute.	Nominal Horse Power.	Undershot Wheel.	Breast Wheel.	Overshot Wheel.	Turbine.
		Effective H. Power.	Effective H. Power.	Effective H. Power.	Effective H. Power.
Cubic Feet.					
5	.0095	.0033	.0052	.00615	.0071
10	.019	.0066	.016	.012	.0142
15	.028	.0099	.015	.018	.021
20	.038	.013	.020	.024	.028
25	.048	.016	.026	.031	.035
30	.057	.020	.031	.037	.042
35	.066	.023	.036	.043	.050
40	.076	.026	.041	.049	.057
45	.085	.030	.046	.055	.064
50	**.095**	**.033**	**.052**	**.061**	**.071**
55	.104	.036	.057	.068	.078
60	.114	.040	.062	.074	.085
65	.124	.043	.067	.080	.092
70	.133	.046	.072	.086	.099
75	.142	.050	.078	.092	.106
80	.152	.053	.083	.098	.113
85	.161	.056	.088	.104	.121
90	.171	.059	.093	.111	.128
95	.180	.063	.098	.117	.135
100	**.190**	**.066**	**.104**	**.123**	**.142**
200	.380	.130	.208	.246	.284
300	.570	.200	.312	.369	.426
400	.760	.260	.416	.492	.568
500	.950	.330	.520	.615	.710
600	1.140	.400	.624	.738	.852
700	1.330	.460	.728	.861	.994
800	1.520	.530	.832	.984	1.136
900	1.710	.590	.936	1.107	1,278
1,000	**1.900**	**.660**	**1.040**	**1.230**	**1.420**
2,000	3.800	1.300	2.080	2.460	2.846
3,000	5.700	2.000	3.120	3.690	4.260
4,000	7.600	2.600	4.160	4.920	5.680
5,000	9.500	3.300	5.200	6.150	7.100
6,000	11.400	4.000	6.240	7.380	8.520
7,000	13.300	4.600	7.280	8.610	9.940
8,000	15.200	5.300	8.320	9.840	11.360
9,000	17.100	5.950	9.360	11.070	12.780
10,000	**19.000**	**6.600**	**10.400**	**12.300**	**14.200**

PRESSURE OF MERCURY AND WATER.—TABLE 13.

EQUIVALENT COLUMNS OF MERCURY & WATER;

With their Pressure per square inch and per square foot.

Applicable to Steam Gauges and Pressure Gauges, for Pumping Engines, and for calculating the strength of Pipes, Tanks, &c., &c.

Column of Mercury.	Equivalent of Water.	Pressure per sq.inch	Pressure per sq.foot.	Column of Mercury.	Equivalent of Water.	Pressure per sq.inch	Pressure per sq.foot.
Inches.	Feet.	lbs.	lbs.	Inches.	Feet.	lbs.	lbs.
.1	.113	.049	7.07	28.56	32.39	**14.00**	2016
.2	.226	.098	14.14	29.00	32.88	14.21	2050
.3	.339	.147	21.21	30.00	33.92	14.70	2121
.4	.452	.196	28.28	30.60	34.71	**15.00**	2160
.5	.565	.245	35.35	31.00	35.05	15.19	2191
.6	.678	.294	42.42	32.00	36.18	15.68	2262
.7	.791	.343	49.49	32.64	37.02	**16.00**	2304
.8	.904	.392	56.56	33.00	37.31	16.17	2333
.9	1.017	.441	63.63	34.00	38.44	16.68	2404
1.0	**1.1306**	**.490**	**70.70**	**34.68**	**39.33**	**17.00**	**2448**
2.0	2.260	.980	141.	35.00	39.57	17.15	2474
2.04	2.314	**1.00**	144	36.00	40.70	17.64	2545
3.0	3 39	1.47	212	36.72	41.62	**18.00**	2592
4.0	4.52	1.96	282	37.00	41.83	18.13	2616
4.08	4.63	**2.00**	288	38 00	42.96	18.62	2686
5.	5.65	2.45	353	38.76	43.96	**19.00**	2736
6.	6.78	2.94	424	39.00	44.09	19.11	2757
6.12	6.94	**3.00**	432	40.00	45.22	19.60	2828
7.	7.91	3.43	495	40.80	46.28	**20.00**	2880
8.	**9.04**	**3.92**	**565**	**42.84**	**48.59**	**21.00**	**3024**
8.16	9.25	**4.00**	576	44.88	50.90	**22.00**	3168
9.	10.17	4.41	636	45.00	50.87	22.05	3181
10.	11.306	4.90	707	46.92	53.21	**23.00**	3312
10.20	11.57	**5.00**	720	48.96	55.52	**24.00**	3456
11.	12.43	5.39	790	50.00	56.53	24.50	3535
12.	13.56	5.88	848	51.00	57.83	**25.00**	3600
12.24	13.88	**6.00**	864	60.00	67.83	29.40	4242
13.	14.69	6.37	919	70.00	79.14	34.30	4949
14.	15.83	6.87	990	80.00	90.44	39.20	5656
14.28	**16.20**	**7.00**	**1,008**	**90.00**	**101.75**	**44.10**	**6363**
15.	16.96	7.36	1,060	100.00	113.06	49.00	7070
16.	18.09	7.85	1,130	110.	124.34	53.90	7777
16.32	18.51	**8.00**	1,152	120.	135.67	58.80	8484
17.	19.22	8.34	1,202	130.	146.70	63.70	9194
18.	20.35	8.83	1,272	140.00	158.	68.70	9898
18.36	20.82	**9.00**	1,296	150.5	170.	73.78	10625
19.	21.48	9.32	1,343	159.3	180.	78.12	11249
20.	22.61	9.81	1,414	168.2	190.	82.46	11874
20.40	23.14	**10.00**	1,440	177.	200.	86,80	12499
21.	**23.74**	10.29	**1,484**	**194.7**	**220.**	**95.48**	**13749**
22.	24.87	10.78	1,555	212.3	240.	104.16	14999
22.44	25.45	**11.00**	1,584	221.3	250.	108.50	15624
23.0	26.00	11.27	1,626	230.1	260.	112.80	16243
24.	27.13	11.76	1,696	247.8	280.	121.50	17496
24.48	27.76	**12.06**	1,728	265.3	300.	130.20	18748
25.00	28.26	12.25	1,767	283.06	320.	138.80	19987
26.	29.39	12.74	1,838		350.	151.90	21873
26.52	30.08	**13.00**	1,872		400.	173.60	24998
27.	30.52	13.23	1,909		450.	195.30	28123
28.	**31.65**	**13.72**	**1979**		**500.**	**217.00**	**31248**

WEIGHT AND STRENGTH OF PIPES—TABLE 14.

WEIGHT PER YARD AND SAFE HEAD OF WATER FOR CAST-IRON PIPES.

Diameters 3 to 48 inches.

NOTE.—The *weight* includes a proportion for socket at every 9 feet, allowing the clear length of each pipe when laid to make 3 yards, thus each pipe would be about 9 feet 6 inches from out to out. The *safe head* is that to which the pipes may be constantly exposed. The proof head may be double the tabular amount if the circumstances require.

Bore.	Thickness.	Weight.			Safe Head of Water.	Bore.	Thickness.	Weight.			Safe Head of Water.
inches.	inches.	cwts.	qrs.	lbs.	feet.	inches.	inches.	cwts.	qrs.	lbs.	feet.
3	1/4	0	1	0	1000	14	5/8	2	2	17	535
	5/16	0	1	14	1500		3/4	3	0	18	642
	3/8	0	2	0	2000		7/8	3	2	19	750
	1/2	0	2	14	2500		1	4	0	21	857
4	1/4	0	1	9	744	15	5/8	2	3	8	500
	5/16	0	1	25	1128		3/4	3	1	12	600
	3/8	0	2	15	1500		7/8	3	3	19	700
	1/2	0	3	5	1872		1	4	1	23	800
5	1/4	0	1	18	600	16	5/8	3	0	0	468
	5/16	0	2	11	900		3/4	3	2	9	565
	3/8	0	3	4	1200		7/8	4	0	18	652
	1/2	1	0	0	1500		1	4	3	0	750
6	5/16	0	2	22	750	18	5/8	3	1	12	412
	3/8	0	3	2	1000		3/4	4	0	0	500
	7/16	1	0	18	1250		7/8	4	2	16	583
	1/2	1	1	18	1500		1	5	0	23	666
7	5/16	0	3	8	640	21	5/8	3	3	18	360
	3/8	1	0	9	857		3/4	4	2	15	428
	7/16	1	1	10	1068		7/8	5	1	15	500
	1/2	1	2	14	1284		1	6	1	14	572
8	5/16	0	3	20	564	24	5/8	4	1	19	312
	3/8	1	0	25	750		3/4	5	1	0	374
	7/16	1	2	3	936		7/8	6	1	0	400
	1/2	1	3	9	1128		1	7	0	13	500
9	5/16	1	0	4	500	30	3/4	6	3	14	300
	3/8	1	1	12	666		1	8	3	24	400
	7/16	1	2	20	832		1 1/8	9	1	16	450
	1/2	2	0	4	1000		1 1/4	11	0	7	500
10	5/16	1	0	16	450	36	3/4	8	0	23	249
	3/8	1	2	0	600		1	10	2	21	333
	7/16	1	3	12	750		1 1/8	11	2	11	375
	1/2	2	1	8	900		1 1/4	13	0	20	412
11	5/16	1	2	15	525	42	3/4	9	3	0	216
	3/8	2	0	4	684		1	12	2	12	288
	7/16	2	1	21	816		1 1/8	14	0	7	312
	1/2	2	3	12	960		1 1/4	15	2	0	360
12	5/16	1	3	3	500	48	3/4	11	0	14	187
	3/8	2	0	23	625		1	14	1	17	250
	7/16	2	2	17	750		1 1/8	16	0	3	280
	1/2	3	0	12	875		1 1/4	17	0	0	312

FLOOD DISCHARGES.—TABLE 15.

DISCHARGE,

IN CUBIC FEET PER MINUTE,

For 1 to 100 Acres, with the following amounts of Rain-fall in 24 hours.

Rain in 24 Hours.	In. 1—32	In. 1—16	In. 1—8	In. 1—4	In. 1—2	In. 3—4	In. 1	Ins. 2	Ins. 3	Ins. 4
Acres.	Cub. ft. per m.	Cub. ft. per m.	Cub. ft. per m.	Cub. ft. per m.	Cub. ft. per m.	Cub. ft. per m.	Cub. ft. per m.	Cub. ft. per m.	Cub. ft. per m.	Cub. ft. per min.
1	.078771	.15754	.31508	.63016	1.26	1.8903	2.52	5.0413	7.5620	10.082
2	.157	.31	.6301	1.26	2.52	3.781	5.04	10.08	15.12	20.1
3	.236	.47	.9452	1.89	3.78	5.671	7.56	15.12	22.68	30.2
4	.315	.63	1.260	2.52	5.04	7.562	10.08	20.16	30.25	40.3
5	.394	.78	1.575	3.15	6.30	9.452	12.60	25.20	37.81	50.4
6	.472	.94	1.890	3.78	7.56	11.34	15.12	30.25	45.37	60.5
7	.551	1.10	2.205	4.41	8.82	13.23	17.64	35.29	52.93	70.6
8	.630	1.26	2.520	5.04	10.08	15.12	20.16	40.33	60.49	80.6
9	.709	1.42	2.835	5.67	11.34	17.01	22.68	45.37	68.06	90.7
10	.788	1.57	3.151	6.30	12.60	18.90	25.20	50.41	75.62	100.8
20	1.575	3.15	6.301	12.60	25.20	37.81	50.41	100.8	151.2	201.6
30	2.363	4.72	9.452	18.90	37.81	56.71	75.62	151.2	226.8	302.5
40	3.150	6.30	12.60	25.20	50.41	75.62	100.8	201.6	302.5	403.3
50	3.938	7.87	15.75	31.51	63.01	94.52	126.0	252.0	378.1	504.1
60	4.726	9.45	18.90	37.81	75.62	113.4	151.2	302.5	453.7	604.9
70	5.514	11.03	22.05	44.10	88.22	132.3	176.4	352.9	529 3	705.8
80	6.301	12.60	25.20	50.41	100.8	151.2	201.6	403.3	604.9	806.6
90	7.090	14.18	28.35	56.71	113.4	170.1	226.8	453.7	680.6	907.4
100	7.877	15.75	31.51	63.01	126.0	189.0	252.0	504.1	756.2	1008.2

For 1 to 10 Square Miles, with the following amounts of Rain-fall in 24 hours.

Rain in 24 Hours.	In. 1—32	In. 1—16	In. 1—8	In. 1—4	In. 3—8	In. 1—2	In. 5—8	In. 3—4	In. 7—8	In. 1
Square Miles.	Cub. ft. per m.	Cub. ft. per m.	Cub. ft. per m.	Cub. ft. per m.	Cub. ft. per m.	Cub. ft. per m.	Cub. ft. per m.	Cub. ft. per m.	Cub. ft. per m.	Cub. ft. per min.
1	50.413	100.82	201.64	403.3	604.96	806.65	1008.26	1209.92	1411.57	1613.23
2	100.8	201.6	403.3	806.6	1209.9	1613.2	2016.5	2419.8	2823.1	3226.4
3	151.2	302.5	604.9	1209.9	1814.9	2419.8	3024.8	3629.7	4234.7	4839.6
4	201.6	403.3	806.6	1613.2	2419.8	3226.4	4033.1	4839.7	5646.3	6452.9
5	252.0	504.1	1008.2	2016.5	3024.7	4033.0	5041.3	6049.6	7057.8	8066.1
6	302.5	604.9	1209.9	2419.8	3629.7	4839.6	6049.6	7259.4	8469.4	9679.3
7	352.9	705.8	1411.5	2823.1	4234.7	5646.3	7057.8	8469.4	9881.0	11292.6
8	403.3	806.6	1613.2	3226.4	4839.7	6452.9	8066.1	9679.3	11292.6	12905.8
9	453.7	907.4	1814.9	3629.7	5444.7	7259.4	9074.4	10889.3	12704.1	14519.0
10	504.1	1008.2	2016.4	4033.0	6049.6	8066.5	10082.6	12099.2	14115.7	16132.3

MEAN DISCHARGE OF ANNUAL RAIN.—Table 16.

DISCHARGES DUE TO RAINFALL

IN DEPTH FROM TWO TO SIXTY INCHES PER ANNUM.

Rain per Annum.	Cubic feet per minute.		Cubic feet per Diem.		Gallons per Diem.	
Inches.	For 1 acre.	For 1 square mile.	For 1 acre.	For 1 square mile.	For 1 acre.	For 1 square mile.
2	.013802	8.83	19.87	12,720	123.8	79,245
4	.027604	17.66	39.75	25,440	257.6	158,491
6	.041406	26.50	59.62	38,160	371.4	237,736
8	.055208	35.33	79.50	50,880	495.2	316,982
10	.069011	44.16	99.37	63,600	619.0	396,228
12	.082813	53.00	119.25	76,320	742.9	475,473
14	.096614	61.83	139.12	89,040	866.6	554,718
16	.110416	70.66	159.00	101,760	990.5	633,964
18	.124219	79,50	178.87	114,480	1114.2	713,210
20	.138022	88.33	198.74	127,200	1238.0	792,456
22	.151824	97.16	218.62	139,920	1362.0	871,701
24	.165626	106.00	238.50	152,640	1485.8	950,947
26	.179427	114.83	258.37	165,360	1609.5	1030,193
28	.193228	123.66	278.24	178,080	1733.2	1109,438
30	.207033	132.50	298.12	190,800	1857.0	1188,684
33	.2277	145.73	327.90	209,851	2042.8	1307,372
36	.248438	159.00	357.75	228,960	2228.7	1426,420
42	.289842	185.50	417.37	267,140	2599.8	1109,437
48	.331252	212.00	477.00	305,280	2971.6	1901 894
54	.372657	238.50	536.62	343,440	3342.6	2139,630
60	.414066	265.00	596.25	381,600	3714.0	2377,368

SUBSOIL DRAINS.—Table C.

LENGTH OF DRAIN PIPES REQUIRED IN ONE ACRE.

No. of feet apart.	Length in feet.	Length in Rods of 16½ feet.
5	8,702	527.3
6	7,262	440.1
8	5,445	330.1
10	4,350	263.6
12	3,631	220.0
15	2,900	175.7
16½	2,640	160.0
18	2,421	146.7
21	2,073	125.6
24	1,815	110.0
27	1,614	97.8
30	1,450	87.8
33	1,314	80.0
36	1,210	73.3

EXPENDITURE OF WATER.—TABLE 17.

DISCHARGE FOR MINUTES, DAYS AND YEARS,

IN CUBIC FEET AND IMPERIAL GALLONS.

PER MINUTE.		PER DIEM.		PER ANNUM.
Cubic Feet.	Gallons.	Cubic Feet.	Gallons.	Cubic Feet. Millions.
1	6.23	1,440	8,974	.526
2	12.46	2,880	17,948	1.052
3	18.69	4,320	26,922	1.578
4	24.92	5,760	35,896	2.104
5	31.16	7,200	44,870	2.630
6	37.39	8,640	53,844	3.156
7	43.62	10,080	62,818	3.682
8	49.85	11,520	71,792	4.208
9	56.08	12,960	80,766	4.734
10	**62.32**	**14,400**	**89,740**	**5.260**
20	124.64	28,800	179,480	10.520
25	155.80	36,000	224,350	13.150
30	186.96	43,200	269,220	15.780
35	218.12	50,400	314,090	18.410
40	249.28	57,600	358,960	21.040
45	280.44	64,800	403,830	23.670
50	311.60	72,000	448,700	26.300
55	342.76	79,200	493,570	28.930
60	373.92	86,400	538,440	31.560
65	**405.08**	**93,600**	**583,310**	**34.190**
70	436.24	100,800	628,180	36.820
75	467.40	108,000	673,050	39.450
80	498.56	115,200	717,920	42.080
85	529.72	122,400	762,790	44.710
90	560.89	129,600	807,660	47.340
95	592.05	136,800	852,530	49.970
100	623.21	144,000	897,408	52.600
200	1,246.4	288,000	1,794,816	105.200
300	1,869.6	432,000	2,692,224	157.800
400	**2,492.8**	**576,000**	**3,589,632**	**210,400**
500	3,116.1	720,000	4,487,040	263.000
600	3,739.2	864,000	5,384,448	315.600
700	4,362.4	1,088,000	6,281,856	368.200
800	4,985.6	1,152,000	7,179,264	420.800
900	5,608.9	1,296,000	8,076,672	473.400
1,000	6,232.1	1,440,000	8,974,080	526.000
2,000	12,464.0	2,880,000	17,948,160	1,052.000
3,000	18,696.0	4,320,000	26,922,240	1,578.000
4,000	24,928.0	5,760,000	35,896,320	2,104.000
5,000	**31,160.0**	**7,200,000**	**44,870,400**	**2,630.000**
6,000	37,392.0	8,640,000	53,844,480	3,156.000
7,000	43,625.	10,080,000	62,818,560	3,682.000
8,000	49,857.	11,520,000	71,792,640	4,208.000
9,000	56,089.	12,960,000	80,766,720	4,734.000
10,000	62,322.	14,400,000	89,740,800	5,260.000
11,000	68,554.	15,840,000	98,714,880	5,786.000
12,000	74,786.	17,280,000	107,688,960	6,312.000

SUPPLY PER DAY, AND EQUIVALENT QUANTITIES PER MINUTE AND YEAR,

IN IMPERIAL GALLONS AND CUBIC FEET;

Also Drainage Area required to provide such Supply at 12 inches depth of Rain running off uniformly per Annum.

Per Day.		Per Minute.		Per Year.	Population.		Drainage area at 12" depth running off per annum.
Millions of Gallons.	Cubic Feet.	Gallons	Cubic Feet.	Millions of Cubic Feet.	At 20 Gallons per Head per day.	At 30 Gallons per Head per day.	
					No.	No.	Sq-miles
.1	16,406	69.44	11.14	5.857	5,000	3,333	.21
.2	32,092	138.89	22.29	11.714	10,000	6,667	.42
.3	48,139	208.33	33.43	17.571	15,000	10,000	.63
.4	64,185	277.78	44.57	23.427	20,000	13,333	.84
.5	80,231	347.22	55.71	29.284	25,000	16,667	1.05
.6	96,277	416.66	66.86	35.141	30,000	20,000	1.26
.7	112,323	486.11	78.00	40.998	35,000	23,333	1.47
.8	128,369	555.55	89.14	46.855	40,000	26,667	1.68
.9	144,416	625.00	100.29	52.712	45,000	30,000	1.89
1.0	**160,462**	**694.44**	**111.43**	**58.567**	**50,000**	**33,333**	**2.10**
1.25	200,579	868.05	139.28	73.209	62,500	41,667	2.62
1.50	240,692	1,041.67	167.14	87.853	75,000	50,000	3.15
1.75	280,808	1,215.28	194.99	102.495	87,500	58,333	3.67
2.00	320,924	1,388.89	222.86	117.137	100,000	66,667	4.20
2.25	361,040	1,562.50	250.71	131.779	112,500	75,000	4.72
2.50	401,158	1,736.11	278.57	146.421	125,000	83,333	5.25
2.75	441,273	1,909.72	306.43	161.063	137,500	91,667	5.77
3.00	481,386	2,083.33	334.30	175.706	150,000	100,000	6.30
3.25	521,502	2,256.94	362.15	190.348	162,500	108,333	6.82
3.50	**561,617**	**2,430.55**	**390.01**	**204.990**	**175,000**	**116,667**	**7.35**
3.75	601,732	2,604.16	417.86	219.632	187,500	125,000	7.87
4.	641,848	2,777.77	445.73	234.275	200,000	133,333	8.40
4.5	722,079	3,124.99	501.45	263.559	225,000	150,000	9.45
5.	802,310	3,472.22	557.16	292.843	250,000	166,667	10.50
5.5	882,541	3,819.44	612.88	322.127	275,000	183,333	11.55
6.	962,772	4,166.66	668.59	351.412	300,000	200,000	12.60
6.5	1,043,003	4,513.88	724.30	380.696	325,000	216,667	13.65
7.	1,123,234	4,861.11	780.00	409.981	350,000	233,333	14.70
8.	1,283,697	5,555.55	891.46	468.549	400,000	266,667	16.81
9.	**1,444,159**	**6,250.00**	**1,002.89**	**527.118**	**450,000**	**300,000**	**18.92**
10.	1,604,621	6,944.4	1,114.3	585.687	500,000	333,333	21.02
20.	3,209,242	13,888.9	2,228.6	1,171.374	1,000,000	666,667	42.04
30.	4,813,863	20,833.3	3,343.0	1,757.061	1,500,000	1,000,000	63.06
40.	6,418,484	27,777.7	4.457.3	2,342.748	2,000,000	1,333,333	84.08
50.	8,023,105	34,722.2	5,571.6	2,928.435	2,500,000	1,666,667	105.10
60.	9,627,726	41,666.6	6,685.9	3,514.122	3,000,000	2,000,000	126.12
70.	11,232,347	48,611.1	7,800.0	4,099.809	3,500,000	2,333,333	147.14
80.	12,836,968	55,555.5	8,914.6	4,685.495	4,000,000	2,666,667	168.16
90.	14,441,589	62,500.0	10,028.9	5,271.181	4,500,000	3,000,000	189.18
100.	**16,046,213**	**69,444.4**	**11,143.2**	**5,856,868**	**5,000,000**	**3,333,333**	**210.20**

VELOCITIES—TABLE 19. GRADIENTS—TABLE 20.

Feet per Minute and miles per Hour.

For feet per second divide by 60
For inches per second divide by 5
For miles per hour multiply by .01136

Feet per min.	Miles per hour	Feet per min.	Miles per hour
10	.1136	280	3.181
11	.1250	300	3.408
12	.1364	320	3.635
13	.1478	340	3.862
14	.1592	360	4.089
15	.1706	380	4.317
16	.1820	400	4.544
17	.1934	420	4.771
18	.2048	440	4.998
19	.2162	460	5.225
20	.2272	480	5.453
25	.2840	500	5.680
30	.3409	550	6.248
35	.3981	600	6.814
40	.4554	650	7.384
45	.5118	700	7.952
50	.5682	750	8.420
55	.6250	800	8.988
60	.6819	850	9.608
65	.7387	900	10.228
70	.7955	950	10.796
75	.8531	1000	11.365
80	.9108	1056	12.
85	.967	1232	14.
90	1.024	1408	16.
95	1.080	1584	18.
100	1.137	1760	20.
105	1.193	1936	22.
110	1.250	2112	24.
115	1.307	2288	26.
120	1.364	2464	28.
125	1.421	2640	30.
130	1.478	2816	32.
135	1.535	2992	34.
140	1.592	3168	36.
145	1.649	3344	38.
150	1.706	3520	40.
155	1.763	3696	42.
160	1.820	3872	44.
165	1.877	4048	46.
170	1.934	4224	48.
175	1.991	4400	50.
180	2.048	4840	55.
185	2.105	5280	60.
190	2.162	5720	65.
195	2.217	6160	70.
200	2.272	6600	75.
220	2.499	7040	80.
240	2.726	7920	90.
260	2.953	8800	100.

Rate and Fall in Feet per Mile and per Chain.

For feet per mile divide 5280 by the rate.
For feet per chain divide 66 by the rate.

Rate.	FALL.		Rate.	FALL.	
one in	Feet per mile.	Feet per chain.	one in	Feet per mile.	Feet per chain.
5	1056	13.2	180	29.3	.366
6	880	11.0	182.1	29.0	.362
7	754.2	9.43	188.6	28	.349
8	666	8.25	190	27.8	.347
9	586.6	7.40	195.6	27	.337
10	528.0	6.66	200	26.4	.330
12	440	5.50	211.2	25	.312
14	377.1	4.71	220	24	.300
16	330	4.13	229.6	23	.288
18	293	3.66	240	22	.275
20	264	3.30	251.4	21	.262
25	211.2	2.64	264	20	.250
30	176	2.20	267.9	19	.237
35	150.8	1.88	293.3	18	.224
40	132	1.65	310.6	17	.212
45	117.3	1.46	330.0	16	.200
50	105.6	1.32	352.0	15	.187
55	96.0	1.20	377.1	14	.175
60	88.0	1.10	406.1	13	.162
65	81.2	1.01	440.0	12	.150
70	75.4	.94	480.0	11	.138
75	70.4	.88	528.0	10	.125
80	66.0	.82	586.7	9	.112
82	64.4	.80	660.0	8	.100
84	62.8	.78	754.3	7	.0874
86	61.4	.76	880.0	6	.0750
88	60.0	.75	960	5.50	.0690
90	58.6	.73	1056	5.00	.0625
92.6	57.0	.71	1173	4.5	.0562
95	55.5	.69	1320	4.0	.0500
96	55.0	.68	1508	3.5	.0437
98	53.8	.67	1760	3.0	.0375
100	52.8	.66	1920	2.75	.0345
101.5	52.0	.65	2112	2.50	.0312
103.5	51.0	.63	2346	2.25	.0281
105.6	50.0	.62	2640	2.	.0250
110	48.0	.60	3017	1.75	.0218
115	45.9	.57	3520	1.5	.0187
120	44.0	.55	4224	1.25	.0156
125	42.2	.52	5280	1.	.0125
				inches.	
130	40.6	.507	5760	11	.0111
135	39.1	.488	6336	10	.0104
140	37.7	.471	7040	9	.0093
145	36.4	.455	7585	8	.0087
150	35.2	.440	9051	7	.0073
155	34.0	.425	10560	6	.0062
160	33.0	.410	12672	5	.0052
165	32.0	.400	15840	4	.0043
170	31.0	.388	21120	3	.0031
176	30.0	.375	31680	2	.0021
			63360	1	.0010

COMPARATIVE MEASURES.—TABLE 21

CHAINS, YARDS, AND FEET,

With their Reciprocal Equivalents, and a Table of Reductions for Slopes.

Link = 7.92 *inches.* *Chain* = 792 *inches.*

Chains into Feet.				Feet into Chains.			For each 100 on Slope.		
Chains	Links.	Yards.	Feet.	Feet.	Yards.	Links.	Rate of Fall.	Angle. Deg. Min.	Deduct.
0.	1	.22	.66	.10	.033	0.15		1.0	.015
0.	2	.44	1.32	.20	.066	0.30		2.0	.061
0.	3	.66	1.98	.25	.082	0.38	1 in 20	2.52	.126
0.	4	.88	2.64	.30	.010	0.45	„ 19	3.01	.137
0.	5	1.10	3.30	.40	.133	0.60	„ 18	3.11	.153
0.	6	1.32	3.96	.50	.166	0.76	„ 17	3.22	.173
0.	7	1.54	4.62	.60	.200	0.91	„ 16	3.35	.198
0.	8	1.76	5.28	.70	.233	1.06	„ 15	3.49	.225
0.	9	1.98	5.94	.75	.250	1.13	„ 14	4.05	.254
0.	**10**	**2.20**	**6.60**	**.80**	**.266**	**1.21**	**„ 13**	**4.24**	**.297**
0.	20	4.40	13.20	.90	.300	1.36	1 in 12	4.46	.343
0.	30	6.60	19.80	1.00	.33	1.51	„ 11	5.12	.406
0.	40	8.80	26.40	2.0	.66	3.0	„ 10	5.45	.503
0.	50	11.00	33.00	3.0	1.000	4.5	„ 9	6.20	.610
0.	60	13.20	39.60	4.0	1.33	6.0	„ 8	7.10	.781
0.	70	15.40	46.20	5.0	1.66	7.5	„ 7	8.10	1.014
0.	80	17.60	52.80	6.0	2.00	9.1	„ 6	9.30	1.373
0.	90	19.80	59.40	7.0	2.33	10.6		10.00	1.519
1.	00	22.00	66.00	8.0	2.66	12.1	1 in 5	11.20	1.950
2		**44.00**	**132**	**9.0**	**3.00**	**13.6**		**12.00**	**2.185**
3.		66.00	198.	10.0	3.33	15.1		13.00	2.563
4.		88.00	264.	15.0	5.00	22.7	1 in 4	14.02	2.980
5.		110.	330.	20.0	6.66	30.3		15.00	3.408
6.		132.	396.	24.0	8.00	36.3		16.00	3.874
7.		154.	462.	27.	9.00	40.9		17.00	4.369
8.		176.	528.	30.	10.00	45.4		18.00	4.894
9.		198.	594.	33.	11.00	50.0	1 in 3	18.26	5.130
10.		220.	660.	36.	12.00	54.5		19.00	5.448
20.		440.	1320.	39.	13.00	59.1		20.60	6.031
30.		**660.**	**1980.**	**40.**	**13.33**	**60.6**		**21.00**	**6.642**
35.		770.	2310.	42.	14.0	63.3		22.00	7.282
40.		880.	2640.	45.	15.00	68.2		23.00	7.949
45.		990.	2970.	48.	16.00	72.7		24.00	8.645
50.		1100.	3300.	50.	16.66	75.7		25.00	9.369
55.		1210.	3630.	51.	17.00	77.3		26.00	10.120
60.		1320.	3960.	54.	18.00	81.8	1 in 2	26.34	10.570
65.		1430.	4290.	57.	19.00	86.3	„	27.00	10.900
70.		1540.	4620.	60.	20.00	90.9	„	28.00	11.645
75.		1650.	4950.	63.	21.00	95.4	1 in 1½	33.41	16.667
80.		**1760.**	**5280.**	**66.**	**22.00**	**100.**	**1 „ 1**	**45.00**	**29.290**

Inches and Fractions expressed in Decimals of a Foot.

NOTE.—The first column gives the decimals corresponding to the fractional parts of units in the next column; thus three-sixteenths is .1875 of an inch.

The remaining columns give the decimals of a foot corresponding to inches and parts: thus $5\frac{3}{4}$ inches = .448 of a foot.
$1\frac{1}{2}$ " = .094 "

Decimals of Unity or an Inch.	Inches.	0	1	2	3	4	5	6	7	8	9	10	11
	Parts.	Foot.	Foot.	Foot.	Foot.	Foot.	Foot.	Foot.	Foot.	Foot.	Foot.	Foot.	Foot.
	0 - 0		.083	.166	.250	.333	.416	.500	.583	.666	.750	.833	.916
.0625	1 - 16	.005208	088	172	255	338	422	505	588	671	755	838	922
.1250	1 - 8	.010416	094	177	260	344	427	510	594	677	760	844	927
.1875	3 - 16	.015625	099	182	265	349	432	515	599	682	765	849	932
.25	1 - 4	.020833	104	187	271	354	437	520	604	687	771	854	937
.3125	5 - 16	.026041	109	193	276	359	443	526	609	692	776	859	943
.3750	3 - 8	.03125	114	198	281	364	448	531	614	697	781	864	948
.4375	7 - 16	.036458	120	203	286	371	457	536	620	703	786	870	953
.5	1 - 2	.04166	125	208	291	375	458	541	625	708	791	875	958
.5625	9 - 16	.046875	130	213	297	380	463	547	630	713	797	880	963
.6250	5 - 8	.052083	135	219	302	385	469	552	635	718	802	885	969
.6875	11 - 16	.057291	140	224	307	390	474	557	640	723	807	890	974
.75	3 - 4	.06250	146	229	312	396	479	562	646	729	812	895	979
.8125	13 - 16	.067708	151	234	318	401	484	568	651	734	818	901	984
.8750	7 - 8	.072916	156	239	323	406	489	573	656	739	823	906	989
.9375	15 - 16	.078125	161	245	328	411	495	578	661	744	828	911	995

Miscellaneous Numbers and Rules.

Length of an Arc = No. of Deg. × Rad. × .01745
Circum. of Circle = Dia. × 3.1416
Area " = Dia² × .7854
Ellipse Area. = T. Axis × C. Axis × .7854
Spheroid Cube = Rev. Axis 3 × f. Axis × .5236
Sphere Surface = Dia² × 3.1416
" Cube = Dia³ × .5236
Parabola Area = ⅔rds of base × height
Paraboloid Cube = ½ base × height
Cone & Pyr. Sur. = ½ girt. of base × slant height
" " Cube = area of base × ⅓ height

Grains in 1 lb. Avoirdupois ..... = 7000
Cubic Inch. in Imperial Gallon .. = 277.274
Do. in Imperial Bushel .. = 2218.192
Lbs. in the Imperial Gallon w ... = 10·003
Lbs. in the Cubic Foot ..... = 62.5
Imperial Gallons in 1 Cubic Foot .. = 6.23
Miles in 1 Degree ..... = 69.044
Length of Seconds Pend. Lat. 51° = 39.13938
" ¼ " " = 9.785
" ½ " " = 4.349
" ¾ " " = 2.446

Reduction of Foreign Measures into English.

French.	*English.*
Millimetre	= 0.03937 inches
Centimetre	= 0.39371 "
Decimetre	= 3.93708 "
Metre	= 39.37079 "
"	= 3.2808 feet
"	= 1.0936 yards
Myriametre	= 6.2138 miles
Toise (old)	= 76.68 inches
Foot (pied.) ..	= 12.78 "
Inch (pouce) ..	= 1.06578 "
Line (ligne) ..	= .088815 "
Cubic Metre ..	= 35.317 cubic feet
Kil. per sq. Millm.	= 1422. lbs. per sq. inch
Litre	= 61.028 cubic inches
Metre, square ..	= 1.196 yards square
" " ..	= 10.764 feet square

French.	*English.*
Are (land)	= 3.95 perches
"	= 119.6 sq. yards
"	= 0.0247 acre
Hectare	= 2.471143 "
Capacity.	
Litre	= 1.760773 pints
"	= 0.2200967 gallons
Decalitre	= 2.201 gallons
Hectolitre	= 22.01 "
"	= 2.7512 bushels
Weight.	
Decigramme ..	= 1.5428 grains
Gramme	= 15.428 "
Kilogramme ..	= 2.6803 lbs. Troy
" ..	= 2.2055 lbs. Avoirdupois
Quintal	= 220.55 " "

Various Nations,	*English.*
Berlin foot ..	= 12.19 inches
Copenhagen ..	= 12.35 "
Dantzic foot ..	= 11.29 "
Hamburgh ft. ..	= 11.29 "
Naples Palm ..	= 10.38 "
Roman foot ..	= 11.60 "
Russian " ..	= 13.75 "
Spanish " ..	= 11.12 "
" vara ..	= 33.272 "
Eng. mile (5280 ft.) = 1760 yards	

Various Nations.	*English*
Nautic. mile (6075.6 ft.) = 2025.2 yards	
Flanders mile ..	= 6869 "
French league ..	= 4263 "
" nautical ..	= 6075 "
German long mile ..	= 10126 "
short " ..	= 6859 "
Irish " ..	= "
Prussian " .	= 8468 "
Russian verst ..	= 1167 "
Spanish league ..	= 4635 "

Areas of Segments of a Circle, and Lengths of Circular Arcs,

Taking diameter as unity for Areas, and base of segments as unity for Lengths.

RULE FOR AREAS.—Multiply the Dia. of the circle of which the given segment is a part, by the tabular area, the result will be the area required.

V. Sin.	Area.	Length.	V. Sin.	Area.	Length.	V. Sin	Area.	Length.
.01	.0013	..	.18	.0961	1.084			
.02	.0037	..	.19	.1039	1.093	.35	.2450	1.300
.03	.0068	..	.20	.1118	1.103	.36	.2545	1.316
.04	.0105	..	.21	.1199	1.114	.37	.2642	1.332
.05	.0147	..	.22	.1281	1.124	.38	.2739	1.349
.06	.0192	1.006	.23	.1364	1.135	.39	.2836	1.366
.07	.0241	1.018	.24	.1449	1.147	.40	.2934	1.383
.08	.0294	1.014	.25	.1535	1.159	.41	.3032	1.401
.09	.0350	1.020	.26	.1623	1.171	.42	.3130	1.418
.10	.0409	1.026	.27	.1711	1.184	.43	.3229	1.437
.11	.0470	1.032	.28	.1800	1.197	.44	.3328	1.455
.12	.0534	1.038	.29	.1890	1.212	.45	.3428	1.474
.13	.0600	1.044	.30	.1981	1.225	.46	.3527	1.493
.14	.0668	1.051	.31	.2074	1.239	.47	.3627	1.512
.15	.0739	1.059	.32	.2167	1.254	.48	.3727	1.531
.16	.0811	1.067	.33	.2260	1.269	.49	.3827	1.551
.17	.0885	1.075	.34	.2355	1.284	.50	.3927	1.571

Length of Degrees and Minutes of an Arc,

RADIUS BEING UNITY.

Deg.	Length.	Min.	Length.
1	0.0174533	1	0.0002909
2	0.0349066	2	0.0005818
3	0.0523599	3	0.0008727
4	0.0698132	4	0.0011636
5	0.0872665	5	0.0014545
6	0.1047198	6	0.0017454
7	0.1221731	7	0.0020363
8	0.1396264	8	0.0023272
9	0.1570797	9	0.0026181
10	0.1745330	10	0.0029090

Height of Apparent above True Level.

The Correction for Refraction is to be applied when necessary.

Dist. Chns.	Subtract Feet.	Dist. Chns.	Subtract Feet.	Dist. Chns.	Subtract Feet.
1	0.00	11	0.012	21	0.045
2	0.00	12	0.015	22	0.050
3	0.001	13	0.018	23	0.055
4	0.002	14	0.020	24	0.060
5	0.003	15	0.023	25	0.065
6	0.004	16	0.027	26	0.070
7	0.005	17	0.030	27	0.075
8	0.007	18	0.033	28	0.080
9	0.008	19	0.037	29	0.085
10	0.010	20	0.041	30	0.090

Square Yards in Decimals of an Acre.

Sq. Yards	Decimal of an Acre.	Sq. Yards	Decimal of an Acre.	Sq. Yards	Decimal of an Acre.
1	.000206				
2	.00041	20	.0041	200	.0413
3	.00062	30	.0062	300	.0619
4	.00083	40	.0083	400	.0826
5	.00103	50	.0103	500	.1033
6	.00124	60	.0124	600	.1239
7	.00144	70	.0144	700	.1446
8	.00165	80	.0165	800	.1653
9	.00185	90	.0185	900	.1859
10	.00206	100	.0206	1000	.2066

BRICKWORK.

1 Rod takes 4,200 to 4,500 Bricks; 270 to 300 Bricks = 1 ton. A rod is 306 c. ft., or 11.33 c. yards.

Wall sup. feet.	Contains Bricks.	
	At 1 Brick.	At 1½ Brick.
1	11	16
2	22	33
3	33	49
4	44	66
5	55	82
6	66	99
7	77	115
8	88	132
9	99	148
10	110	165

TABLE 23.

TABLE FOR CONVERTING THE SCALES OF FAHRENHEIT, CENTIGRADE AND REAUMUR THERMOMETERS.

RULE.—For converting degrees Fahrenheit into Centigrade or Reaumur, deduct 32° therefrom, and look for the value of the remainder in the Table.

Example.—To convert 78° Fahr. 78°—32°=46°; then in column 6, opposite 4 in the column of tens, will be found 25° 56 Centig. or 20° 44 Reaum.

Note.—When the degrees Fahr. are less than 32° all readings are *minus*, or below zero of Centig. and Reaum.

For converting Centig. or Reaum. into Fahr.—To the value of the degrees Centig. or Reaum. obtained from the respective Tables as above, add 32° and the sum will be the equivalent degrees Fahr.

Example.—To convert 50° Centig. or 40° Reaum. into Fahr.—In column 0, opposite 5 in the column of tens for Centig. or 4 for Reaum. will be found 90.00, to which add 32° and the sum 122° is the equivalent reading in degrees Fahr.

Fahrenheit into Centigrade.

Tens.	UNITS. 0	1	2	3	4	5	6	7	8	9
0	0.00	0.56	1.11	1.67	2.22	2.78	3.33	3.89	4.44	5.00
1	5.56	6.11	6.67	7.22	7.78	8.33	8.89	9.44	10.00	10.56
2	11.11	11.67	12.22	12.78	13.33	13.89	14.44	15.00	15.56	16.11
3	16.67	17.22	17.78	18.33	18.89	19.44	20.00	20.56	21.11	21.67
4	22.22	22.78	23.33	23.89	24.44	25.00	25.56	26.11	26.67	27.22
5	27.78	28.33	28.89	29.44	30.00	30.56	31.11	31.67	32.22	32.78
6	33.33	33.89	34.44	35.00	35.56	36.11	36.67	37.22	37.78	38.33
7	38.89	39.44	40.00	40.56	41.11	41.67	42.22	42.78	43.33	43.89
8	44.44	45.00	45.56	46.11	46.67	47.22	47.78	48.33	48.89	49.44
9	50.00	50.56	51.11	51.67	52.22	52.78	53.33	53.89	54.44	55.00
10	55.56	56.11	56.67	57.22	57.78	58.33	58.89	59.44	60.00	60.56
Decimls	00.00	.0556	.111	.167	.222	.278	.333	.389	.444	.500

Centigrade into Fahrenheit.

0	0.0	1.8	3.6	5.4	7.2	9.0	10.8	12.6	14.4	16.2
1	18.0	19.8	21.6	23.4	25.2	27.0	28.8	30.6	32.4	34.2
2	36.0	37.8	39.6	41.4	43.2	45.0	46.8	48.6	50.4	52.2
3	54.0	55.8	57.6	59.4	61.2	63.0	64.8	66.6	68.4	70.2
4	72.0	73.8	75.6	77.4	79.2	81.0	82.8	84.6	86.4	88.2
5	90.0	91.8	93.6	95.4	97.2	99.0	100.8	102.6	104.4	106.2
6	108.0	109.8	111.6	113.4	115.2	117.0	118.8	120.6	122.4	124.2
7	126.0	127.8	129.6	131.4	133.2	135.0	136.8	138.6	140.4	142.2
8	144.0	145.8	147.6	149.4	151.2	153.0	154.8	156.6	158.4	160.2
9	162.0	163.8	165.6	167.4	169.2	171.0	172.8	174.6	176.4	178.2
10	180.0	181.8	185.6	185.4	187.2	189.0	190.8	192.6	194.4	196.2
Decimls	0.000	.18	.36	.54	.72	.90	1.08	1.26	1.44	1.62

Fahrenheit into Reaumur.

0	0.00	.44	.89	1.33	1.78	2.22	2.67	3.11	3.56	4.00
1	4.44	4.89	5.33	5.78	6.22	6.67	7.11	7.56	8.00	8.44
2	8.89	9.33	9.78	10.22	10.67	11.11	11.56	12.00	12.44	14.89
3	13.33	13.78	14.22	14.67	15.11	15.56	16.00	16.44	16.89	17.33
4	17.78	18.22	18.67	19.11	19.56	20.00	20.44	20.89	21.33	21.78
5	22.22	22.67	23.11	23.56	24.00	24.44	24.89	25.33	25.78	26.22
6	26.67	27.11	27.56	28.00	28.44	28.89	29.33	29.78	30.22	30.67
7	31.11	31.56	32.00	32.44	32.89	33.33	33.78	34.22	34.67	35.11
8	35.56	36.00	36.44	36.89	37.33	37.78	38.22	38.67	39.11	39.56
9	40.00	40.44	40.89	41.33	41.78	42.22	42.67	43.11	43.56	44.00
10	44.44	44.89	45.33	45.78	46.22	46.67	47.11	47.56	48.00	48.44
Decimls	0.000	.044	.089	.133	.178	.222	.267	.311	.356	.400

Reaumur into Fahrenheit.

0	0.00	2.25	4.50	6.75	9.00	11.25	13.50	15.75	18.00	20.25
1	22.50	24.75	27.00	29.25	31.50	33.75	36.00	38.25	40.50	42.75
2	45.00	47.25	49.50	51.75	54.00	56.25	58.50	60.75	63.00	65.25
3	67.50	69.75	72.00	74.25	76.50	78.75	81.00	83.25	85.50	87.75
4	90.00	92.25	94.50	96.75	99.00	101.25	103.50	105.75	108.00	110.25
5	112.50	114.75	117.00	119.25	121.50	123.75	126.00	128.25	130.50	132.75
6	135.00	137.25	139.50	141.75	144.00	146.25	148.50	150.75	153.00	155.25
7	157.50	159.75	162.00	164.25	166.50	168.75	171.00	173.25	175.50	177.75
8	180.00	182.25	184.50	186.75	189.00	191.25	193.50	195.75	198.00	200.25
9	202.50	204.75	207.00	209.25	211.50	213.75	216.00	218.25	220.50	222.75
10	225.00	227.25	229.50	231.75	234.00	236.25	238.50	240.75	243.00	245.25
Decimls	0.000	.225	.450	.675	.900	1.125	1.350	1.575	1.800	2.025

Table 24.

TABLE FOR CONVERTING ENGLISH AND FRENCH MEASURES.

Note.—The values of units only are given in this Table; for higher numbers multiply the values of the units of which the number is composed by 10, 100, &c., as may be necessary, and add together the several results. Thus, value in mètres of 156 feet:—

$$156 = \begin{cases} 1 \times 100 = .30479 \times 100 = 30.47900 \\ 5 \times 10 = 1.52397 \times 10 = 15.23970 \\ 6 \times 1 = 1.82877 \end{cases}$$

47.54747 mètres.

Units.	Feet into mètres.	Inches into centimètres.	Inches into F. lines.	E. inches into F. inches.	Miles into kilomètres.	Chains into mètres.
1	.30479	2.5400	11.2594	.9383	1.6093	20.1165
2	.60959	5.0799	22.5188	1.8766	3.2186	40.2329
3	.91438	7.6199	33.7781	2.8149	4.8279	60.3494
4	1.21918	10 1598	45.0374	3.7532	6.4372	80.4659
5	1.52397	12.6998	56.2968	4.6914	8.0464	100.5823
6	1.82877	15.2397	67.5562	5.6297	9.6557	120.6988
7	2.13356	17.7797	78.8155	6.5680	11.2650	140.8153
8	2.43836	20.3196	90.0749	7.5063	12.8743	160.9318
9	2.74315	22.8596	101.3342	8.4446	14.4836	181.0482
10	3.04794	25.3995	112.5936	9.3829	16.0929	201.1647

Units.	Mètres into feet.	Centimètres into inches.	F. lines into inches.	F. inches into E. inches	Kilomètres into miles.	Mètres into chains.
1	3.2809	.39371	.088814	1.0658	.6214	.04971
2	6.5618	.78742	.177628	2.1315	1.2428	.09942
3	9.8427	1.18112	.266442	3.1973	1.8641	.14913
4	13.1236	1.57483	.355256	4.2631	2.4855	.19884
5	16.4045	1.96854	.444070	5.3288	3.1069	.24855
6	19.6854	2.36225	.532884	6.3946	3.7283	.29827
7	22.9663	2.75596	.621698	7.4604	4.3496	.34798
8	26.2472	3.14966	.710512	8.5261	4.9710	.39769
9	29.5281	3.54337	.799326	9.5919	5.5924	.44740
10	32.8090	3.93708	.888140	10.6577	6.2138	.49711

Units.	Sq. feet into sq. mètres.	Sq. inches into sq. centimètres.	Acres into hectares.	Sq. miles into sq. kilomètres.	Cubic feet into cubic mètres.	Gallons into decalitres.
1	0.0929	6.4516	.40467	2.5898	.028315	.45435
2	0.1858	12.9032	.80934	5.1797	.056630	.90879
3	0.2787	19.3548	1.21401	7.7695	.084945	1.36304
4	0.3716	25.8065	1.61868	10.3594	.113260	1.81738
5	0.4645	32.2581	2.02335	12.9492	.141575	2.27173
6	0.5574	38.7097	2.42802	15.5391	.169890	2.72607
7	0.6503	45.1613	2.83269	18.1289	.198205	3.18042
8	0.7432	51.6129	3.23736	20.7188	.226520	3.63476
9	0.8361	58.0645	3.64203	23.3086	.254835	4.08911
10	0.9290	64.5161	4.04670	25.8985	.283150	4.54345

Units.	Sq. mètres into sq. feet.	Sq. centimètres into sq. inches.	Hectares into acres.	Sq. kilomètres into sq. miles.	Cubic mètres into cubic feet.	Decalitres into gallons.
1	10.7643	.15501	2.4711	.3861	35.317	2.2010
2	21.5286	.31002	4.9423	.7722	70.633	4.4019
3	32.2929	.46502	7.4134	1.1583	105.950	6.6029
4	43.0572	.62003	9.8846	1.5444	141.266	8.8039
5	53.8215	.77504	12.3557	1.9305	176.583	11.0048
6	64.5858	.93005	14.8269	2.3167	211.900	13.2058
7	75.3501	1.08506	17.2980	2.7028	247.216	15.4068
8	86.1144	1.24006	19.7691	3.0889	282.533	17.6077
9	96.8787	1.39507	22.2403	3.4750	317.849	19.8087
10	107.6430	1.55008	24.7114	3.8611	353.166	22.0097

FRENCH MEASURES INTO ENGLISH.—TABLE 25.

MÈTRES CUBES.

Mètres Cubes per Diem.	Gallons per Diem.	Cubic Feet per Min.
1	220.0	.02
2	440.0	.05
3	660.0	.07
4	880.0	.10
5	1,100.1	.12
6	1,320.1	.14
7	1,540.1	.17
8	1,760.1	.19
9	1,980.2	.22
10	**2,200.2**	**.25**
20	4,400.4	.50
30	6,600.6	.73
40	8,800.8	1.00
50	11,001.0	1.22
60	13,201.2	1.47
70	15,401.4	1.71
80	17,601.6	2.00
90	19,801.8	2.20
100	22,002.0	2.45
200	**44,004.0**	**4.90**
300	66,006.0	7.35
400	88,008.0	9.80
500	110,010.0	12.25
600	132,012.0	14.70
700	154,014.0	17.15
800	176,016.0	19.60
900	198,018.0	22.01
1,000	220,020.0	24.50

HECTOLITRES.

Hect'litres per Diem.	Gallons per Diem.	Cubic Feet per Min.
1	22.0	.002
2	44.0	.005
3	66.0	.007
4	88.0	.010
5	110.0	.012
6	132.0	.014
7	154.0	.017
8	176.0	.019
9	198.0	.022
10	**220.0**	**.025**
20	440.0	.050
30	660.0	.073
40	880.0	.100
50	1,100.1	.12
60	1,320.1	.14
70	1,540.1	.17
80	1,760.1	.20
90	1,980.2	.22
100	2,200.2	.24
200	**4,400.4**	**.049**
300	6,600.6	.73
400	8,800.8	.98
500	11,001.0	1.22
600	13,201.2	1.47
700	15,407.0	1.71
800	17,601.6	1.96
900	19,801.8	2.20
1,000	22,002.0	2.45

VALUE OF THE MÈTRE CUBE.

Price per Mètre Cube.	Price per 100 Mètres C.	Price per 1,000 Gallons.
Fr. Cents.	Fr. Cents.	Pence.
0 1	10 0	.433
0 2	20 0	.866
0 3	30 0	1.299
0 4	40 0	1.732
0 5	**50 0**	**2.165**
0 6	60 0	2.598
0 7	70 0	3.031
0 8	80 0	3.664
0 9	90 0	3.89
0 10	100 0	4.33

VALUE OF THE HECTOLITRE.

Price per Hectolitre.	Price per 1,000 Hectolitres	Price per 1,000 Gallons.
Fr. Cents.	Fr. Cents.	s. d.
0 1	10 0	0 4.3
0 2	20 0	0 8.6
0 3	30 0	1 0.9
0 4	40 0	1 5.3
0 5	**50 0**	**1 9.6**
0 6	60 0	2 1.9
0 7	70 0	2 6.3
0 8	80 0	3 0.6
0 9	90 0	3 2.9
0 10	100 0	3 7.3

METALS, BUILDING MATERIALS, FLUIDS, &c.

TABLES OF VARIOUS PROPERTIES.

The different qualities of materials in these tables express an average, from the best authorities, and in many cases from original experiments. Allowance must be made, in many cases, for the nature of the materials, when applying the tables, as many are in their nature variable.

Tenacity varies as the sectional area.

Transverse strength as the square of the depth ÷ by the length for rectangular beams; or as the cube of the diameter ÷ by the length in cylindric beams.

Resistance to crushing increases generally in a much more rapid ratio than the area.

The multipliers for transverse strength give the breaking weight for rectangular beams, *fixed at one end and loaded at the other*; thus, $\frac{\text{Tab. No.} \times b \times d^2}{\text{length}}$ = breaking weight in lbs.;

When *fixed at one end and uniformly loaded*, take *twice* the tabular number.
When *supported at both ends and loaded in the middle*, take *four times* the tabular number.
When *supported at both ends and uniformly loaded*, take *eight times* the tabular number.

NOTE.—Safe load should not be more than one-fourth to one-sixth of the breaking weight.

METALS.	Specific Gravity.	Weight of a cubic Foot in lbs.avds.	Melting Point. Fah.	Tenacity per Sq. Inch in lbs.	Crushing Force per Sq. Inch.	Expansion 32° to 212°.
Antimony, Cast	6.600	418	810°	1066		1.0011
Bismuth, Cast.....	9.810	613	472	3250		1.0014
Brass	8.399	525	1869	17968	10304	1.0020
Copper	8.607	538	2548	19072*		1.0018
Gold, Pure	19.253	1203	2590	20450		1.0016
Gold Coin	17.647				TONS.	
Iron, Cast (variable)	7.104	444	3479	13440 to 23000	40 to 50	1.0011†
Iron, Swedish.....	7.600			68000		
Iron, Malleable, best Bar	7.700	481		60000‡	20 to 30	1.0012
Lead	11.446	717	612	1824		1.0028
Mercury, Fluid	13.568	848				1.0160§
Platinum, Purified...	20.250	1219	wire	56000		1.0009
Silver, Standard.....	10.300	644	1280°	40900		1.0019
Steel, Soft	7.800	490		120000		1.0011
Tin	7.291	455	442	5322		1.0022
Zinc.....	7.028	439	700°	16090 to 20000		1.0029

* Wrought Copper Tenacity 33,000 lbs. † Shrinks, when cast, ¼ inch per foot.

‡ Tenacity of Common Bar (say) 15 tons per square inch; Elastic Power (say) two-thirds of ultimate strength; Best Iron one-half. Compression begins at 10 to 12 tons.

Multipliers for transverse strength.
Cast Iron average 8,000.
Wrought Iron average 16,000.

§ Boils at 660°; expansion of glass tube 32° to 212° = 1.0008.

WEIGHT, STRENGTH, &c. OF MATERIALS.—TABLE 26

BUILDING AND OTHER MATERIALS.	Specific Gravity.	Weight of a Cubic Foot in lbs.	No. of Feet in a Ton.	Crushing force per Square Inch, in lbs.	REMARKS.
Alabaster	2.699	168	13.3		Crushing force of fire-bricks as high as 5,500 lbs. (Buchanan.)
Basalt	2.864	179	12.5		
Brick	1.557	97	23.0	1500	
	2.168	135	16.6	2000	
Brickwork, in Cement	1.680	105	21 4		**Mortar.**
Do. in Mortar	1.568	98	22.9		c feet 1 Dorking Lime 3 Sand 1 Water
Concrete, Portld. Cement	2.272	142	15.8		
Do. common Lime.	1.900	120	18.6		
Cement, Portland	1.280	80	28.0		
Do. Roman	1.040	65	34.4		5 Total, will make 2.9 cubic feet of Mortar, or dry materials to Mortar, as 4 to 3, nearly.
Chalk	2.315	145	15.4	500	
Clay, Medway	1.440	90	25.0		
Do. common	2.000	125	17.0		
Coal, Newcastle	1.257	78	28.7		
Do. Welsh	1.337	83	27.		**Flooring.**
Do. Cannel	1.300	81	27.6		80 lbs. per foot superficial.
	1.400	89	25.2		
Coke	.744	46			
Earth, rammed	1.584	99	22.6		**Glass.**
Flint	2.630	164			Expansion 32° to 212°—.00086.
Flooring	..	..			
Glass, plate	2.453	153			
Gravel	1.900	120	18.6		**Crushing Weights**
Granite, Cornish	2.662	166	13.5		
Do. Aberdeen	2.625	164	13.5	8000	are probably a minimum, as strength increases more than as the square of the dimensions.
Do. Red Egyptian	2.654	166	13.5		
Lime, of Stone	.483	53	42.2		
Do. of Chalk	.704	44	51.0		
Limestone, Bolsover	2.316	145	15.4		
Do. Blue lias	2.467	154	14.5		**Lime.**
Do. Plymouth	2.677	169	13.2		70 lbs. p. bsh. Stone
Do. Statuary marble.	2.638	165	13.5	6400	56 lbs. „ Chalk
Do. Purbeck	2.601	163	13.7		
Marl	1.600	100	22.4		**Sand**
	2.800	170	13.2		Shrinks one-third if wetted.
Mortar	1.751	107	21.0		
Oolite, Bath	1.839	115	19.5		
Do. Portland	2.145	134	16.6	3729	
Porphyry	2.765	173	12.9		**Roofing.**
Pozzolano	1.444	90	25.0		For force *per* of wind *sq. ft.* take .. 40 lbs. Slating .. 12 „ Plain tiling 17 „
Sand, River	1.886	118	19.2		
Roofing	..	..			
Sandstone, Bramley Fall	2.506	156	14.4		
Do. Darley Dale	2.628	164	13.5		Great wrought-iron roof of Lime-street railway station, 153.5 ft. span; length 374 feet; principals 21.5 ft. apart; weight of iron in each principal 10 tons; cost £22 per square; proof load 72 lbs. per foot sup.
Do. Craigleith	2.266	142	15.8	5800	
Do. York Landing	2.320	145	15.4		
Serpentine, Green	2.574	164	13.6		
Shingle	1.424	89	25.2		
Slate, Welsh and Valencia	2.888	180	12.4		
Do. Westmoreland	2.791	174	12.7		
Sulphur	2.033	127	17.6		
Tile	1.815	113	20.0		

WEIGHT, STRENGTH, &c. OF MATERIALS.—TABLE 26

TIMBER.	Specific Gravity.	Weight of a Cubic Foot in lbs.	No. of Feet in a Ton.	Tenacity per square inch in lbs.	Crushing force per square inch in lbs.	Multiplier for Transverse Strength.
Alder	.800	50.0	44.8	14186	6895	..
Ash	.767	49.0	45.7	17207	9023	2026
Beech	.777	43.12	51.0	16817	9048	1560
Birch	.792	49.5	45.2	15000	4567	1900
Box	.960	60.0	37.3	19891	10299	..
Ebony	1.250	70.4	30.0	..	..	..
Cork	.240	15.0	..	..	..	..
Elm	.588	36.7	61.0	13489	10331	1030
Larch	.522	32.6	68.6	10220	..	900
Lance Wood	1.022	63.9	35.1	24696	..	..
Lignum Vitæ	1.220	76.2	29.3	11800	..	..
Mahogany, Spanish	.800	50.0	44.8	16500	8198	..
Do. Honduras	.560	35.0	64.0	8700	..	..
Oak, English	.934	58.3	38.3	17300	..	1800
Do. Canadian	.872	54.5	41.1	10253	..	1760
Do. Dantzic	.756	47.2	47.4	12780	..	1450
Do. African	.972	60.7	36.8	..	..	2000
Green Heart	1.000	62.5	35.0	..	..	2700
Pine, Red	.657	41.0	54.5	..	5375	1340
Do. American Yellow	.461	28.8	77.7	..	5445	..
Plane Tree	.640	40.0	56.0	11700	..	..
Sycamore	.690	43.1	52.0	13000	..	..
Teak	.657	41.0	54.5	15000	12101	2460
Walnut	.671	41.9	53.4	8130	6645	..

FLUIDS.			Boiling Point.	Expansion 32° to 212°.	REMARKS.
Alcohol, Commercial	.837	52.3	173°	1.110	
Ammonia	.897	56.1	..	..	
Ether, Sulphuric	.739	46.3	100°	1.070	
Milk	1.032	64.5	..	..	
Muriatic Acid	1.194	75.0	222°	1.060	
Naptha	..	..	..	..	
Olive Oil	.915	57.2	..	1.080	
Sperm Oil	.872	54.5	..	1.080	
Sulphuric Acid	1.841	115.6	..	1.060	
Turpentine, Spirit	.870	54.9	316°	1.070	
Water, Rain	1.000	62.5	212°	1.047	at 77° exp. 1.003
Do. Sea	1.026	64.1	213°.2	..	
Ice	.940	58.7			

GASES.		Grains.			To convert moist air or gas into dry:—
Air	1.000	525.0	..	1.375	
Ammoniacal Gas	0.596	319.8	..	Do.	
Carbonic Acid	1.524	800.1	..	Do.	
Chlorine	0.470	246.7	..	Do.	Deg. Deg. Multiply
Carburetted Hydrogen	0.420	220.5	..	Do.	53 to 57 - .986
Hydrogen	0.069	43.7	..	Do.	57 to 63 - .980
Oxygen	1.103	627.8	..	Do.	64 to 69 - .976
Sulphureous Acid	2.234	1207.9	..	Do.	69 to 73 - .974

MALLEABLE IRON, FOR ONE FOOT IN LENGTH.

For weight of cast iron, multiply by .95
" steel " 1.02
" copper " 1.13

For weight of brass multiply by 1.08
" lead " 1.50
" zinc " .92

ROUND AND SQUARE BAR.

Size.	Round.	Square.	Size.	Round	Square
ins.	lbs.	lbs.	ins.	lbs.	lbs.
	0.7	**0.8**	**5**	**67**	**84**
	1.0	1.3	5 1/8	69	88
	1.5	1.9	5 1/4	73	93
1/8	2.0	2.6	5 3/8	76	97
1	**2.7**	**3.4**	**5 1/2**	**81**	**102**
1 1/8	3.4	4.3	5 5/8	84	107
1 1/4	4.2	5.3	5 3/4	88	111
1 3/8	5.0	6.4	5 7/8	91	116
1 1/2	**6.0**	**7.6**	**6**	**95**	**121**
1 5/8	7.0	8.9	6 1/4	103	132
1 3/4	8.1	10.4	6 1/2	112	142
1 7/8	9.3	11.9	6 3/4	121	154
2	**10.6**	**13.5**	**7**	**130**	**165**
2 1/8	12.0	15.3	7 1/4	139	177
2 1/4	13.4	17.1	7 1/2	149	190
2 3/8	15.0	19.1	7 3/4	159	203
2 1/2	**16.7**	**21.1**	**8**	**170**	**216**
2 5/8	18.3	23.3	8 1/4	180	230
2 3/4	20.1	25.6	8 1/2	192	244
2 7/8	21.9	27.9	8 3/4	203	258
3	**23.9**	**30.4**	**9**	**215**	**273**
3 1/8	25.9	33.0	9 1/4	227	289
3 1/4	28.0	35.7	9 1/2	239	305
3 3/8	30.2	38.5	9 3/4	252	321
3 1/2	**32.5**	**41.4**	**10**	**266**	**337**
3 5/8	34.9	44.4	10 1/4	278	355
3 3/4	37.3	47.5	10 1/2	292	372
3 7/8	39.9	50.8	10 3/4	306	390
4	**42.5**	**54.1**	**11**	**321**	**409**
4 1/8	45.2	57.5	11 1/4	336	427
4 1/4	48.0	61.1	11 1/2	351	447
4 3/8	50.8	64.7	11 3/4	366	466
4 1/2	**53.8**	**68.4**	**12**	**382**	**486**
4 5/8	56.8	72.3	13	447	570
4 3/4	60.0	76.3	14	515	661
4 7/8	63.1	80.3	15	596	758

WEIGHT OF CAST IRON BALLS.

Size.	Weight.	Size.	Weight.
ins.	lbs.	ins.	lbs.
1	0.136	6	29.50
2	1.10	7	47.00
3	3.70	8	70.00
4	8.70	9	100.00
5	17.10	10	137.00

FLAT BAR.

Wide	1/4 Thick.	3/8 Thick.	1/2 Thick.	5/8 Thick.	3/4 Thick.
ins.	lbs.	lbs.	lbs.	lbs.	lbs.
1	**0.8**	**1.3**	**1.7**	**2.1**	**2.5**
1 1/4	1.1	1.6	2.1	2.6	3.2
1 1/2	1.3	1.9	2.5	3.2	3.8
1 3/4	1.5	2.2	3.0	3.7	4.4
2	**1.7**	**2.5**	**3.4**	**4.2**	**5.1**
2 1/4	1.9	2.9	3.8	4.8	5.7
2 1/2	2.1	3.2	4.2	5.3	6.3
2 3/4	2.3	3.5	4.6	5.8	7.0
3	**2.5**	**3.8**	**5.1**	**6.3**	**7.6**
3 1/4	2.7	4.1	5.5	6.9	8.2
3 1/2	3.0	4.4	5.9	7.4	8.9
3 3/4	3.2	4.8	6.3	7.9	9.5
4	**3.4**	**5.1**	**6.8**	**8.4**	**10.1**
4 1/4	3.6	5.4	7.2	9.0	10.8
4 1/2	3.8	5.7	7.6	9.5	11.4
4 3/4	4.0	6.0	8.0	10.0	12.0
5	**4.2**	**6.3**	**8.4**	**10.6**	**12.7**
5 1/4	4.4	6.7	8.9	11.1	13.3
5 1/2	4.6	7.0	9.3	11.6	13.9
5 3/4	4.9	7.3	9.7	12.1	14.6
6	**5.1**	**7.6**	**10.1**	**12.7**	**15.2**

SHEET METALS.—Foot Sup.

Wire gauge	Thickness.	Iron.	Copper.	Brass	Lead.
No.	ins. dec.	lbs.	lbs.	lbs.	lbs.
	1	40	45.20	43.2	60.
	7-8	35	39.55	37.8	52.5
	3-4 .75	30	33.90	32.4	45.
	5-8	25	28.25	27.0	37.5
	1-2 .50	20	22.60	21.6	30.
	7-16	17.5	19.77	18.9	26.25
	3-8	15.0	16.95	16.2	22.5
1	5-16.30	12.5	14. 5	13.8	18.75
2	.29	12.2	13. 8	13.3	18.3
4	1-4 .25	10.0	11. 3	10.8	15.
6	.21	8.3	9. 4	8.9	12.45
7	3-16.19	7.5	8. 5	8.1	11.25
8	.17	6.6	7. 4	7.1	9.90
10	.13	5.5	6. 2	5.9	8.25
11	1-8 .12	5.0	5. 6	5.4	7.50
12	.11	4.3	4. 8	4.6	6.65
14	.08	3.2	3. 6	3.4	4.80
16	1-16.06	2.5	2. 8	2.7	3.75
18	.05	1.9	2. 1	2.0	2.85
20	.03	1.5	1. 7	1.7	2.25
22	1-32	1 2	1. 3	1.4	1.80

WEIGHT OF WIRE PER 100 FEET,

With Diameter and Area of the Birmingham Wire Gauges, and Tensile Breaking Weight.

Birm. Wire Gauge.	Diam.	Area.	IRON.		STEEL.		COPPER.	
			Weight.	Tensile Bkg. Wt.	Weight.	Tensile Bkg. Wt.	Weight.	Tensile Bkg. Wt.
in.	ins.	sq. ins.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1 sq. in.	1.000	1.00000	334.00	80,000	339.00	120,000	389.66	33,000
1 cir. in.	1.000	.78540	262.40	62,832	266.25	94,248	304.45	25,918
0000	.454	.16189	54.07	12,951	54.88	19,427	62.80	5,342
000	.425	.14186	47.38	11.349	48.09	17,023	55.02	4,681
00	.380	.11341	37.77	9,073	38.45	13,609	43.98	3,742
0	.340	.09079	30.53	7,263	30.78	10,895	35.20	2,996
1	.300	.07068	23.54	5,654	23.96	8,481	27.40	2,332
2	.284	.06335	21.10	5,068	21.48	7,602	24.56	2,090
3	.259	.05628	17.54	4,502	19.08	6,753	20,43	1,857
4	.238	.04449	14.81	3,559	15.08	5,339	17.23	1,468
5	.220	.03801	12.27	3,041	12.89	4,561	14.74	1,254
6	.203	.03236	10.66	2,589	10.97	3,883	12.55	1,068
7	.185	.02688	8.60	2,150	9.11	3,225	9.89	887
8	.167	.02190	7.24	1,752	7.42	2,628	8.29	723
9	.148	.01720	5.76	1,376	5.83	2,064	6.67	624
10	.134	.01410	4.78	1,128	4.78	1,692	5.46	465
11	.120	.01131	3.77	905	3.83	1,357	4.37	373
12	.109	.00933	3.10	746	3.16	1.119	3.60	308
13	.095	.00709	2.33	567	2.40	851	2.70	234
14	.083	.00541	1.80	433	1.83	649	2.04	178
15	.072	.00407	1.35	325	1.38	488	1.56	134
16	.065	.00332	1.10	265	1.12	398	1.25	110
17	.058	.00264	.87	211	.89	316	1.00	87
18	.049	.00189	.63	151	.64	227	.71	62
19	.042	.00138	.45	110	.47	165	.53	46
20	.035	.00096	.32	77	.33	115	.36	32
21	.032	.00080	.26	64	.27	96	.30	26
22	.028	.00061	.20	49	.21	73	.23	20
23	.025	.00049	.16	39	.17	59	.18	16

Specific Gravity—Water 1.000; Iron 7.70; Steel 7.816; Copper 8.91.

WEIGHT OF EQUAL SIDED ANGLE AND T IRON PER FOOT IN LENGTH.

Thickness of Metal.	1/4 Inch.		5/16 Inch.		3/8 Inch.		7/16 Inch.		1/2 Inch.		5/8 Inch.		3/4 Inch.	
Sides.	Area	Wgt.	Area	Wgt.	Area	Wgt.	Area	Wgt.	Area	Wgt.	Area	Wgt.	Area	Wgt.
ins.	s. in.	lbs.	s. in.	lbs.	s. in.	lbs.	s. in.	lbs.	s. in.	lbs.	s. in.	lbs.	s. in.	lbs.
1½	.69	.69	.84	2.82	.99	3.31	1.12	3.77	1.26	4.20	...	...	...	...
1¾	.81	.81	1.00	3.35	1.18	3.94	1.35	4.51	1.51	5.04	...	...	...	...
2	.94	3.15	1.16	3.88	1.37	4.57	1.57	5.24	1.76	5.88	2.12	7.09	2.45	8.19
2¼	1.06	3.51	1.32	4.46	1.50	5.11	1.78	5.98	2.01	6.72	2.44	8.14	2.82	9.45
2½	1.19	3.95	1.47	4.92	1.74	5.83	2.00	6.71	2.26	7.56	2.75	9.19	3.05	10.71
2¾	1.32	4.41	1.63	5.45	1.93	6.46	2.23	7.45	2.51	8.40	3.07	10.24	3.58	11.97
3	1.44	4.83	1.78	5.97	2.12	7.09	2.44	8.18	2.77	9.24	3.38	11.29	3.96	13.23
3¼	1.57	5.25	1.94	6.50	2.31	7.72	2.65	8.92	3.02	10.08	3.69	12.34	4.34	14.49
3½	1.69	5.67	2.10	7.02	2.50	8.35	2.85	9.65	3.28	10.92	4.01	13.39	4.72	15 75
3¾	1.82	6.09	2.26	7.55	2.69	8.98	3.10	10.39	3.52	11.76	4.32	14.44	5.11	17.01
4	1.95	6.51	2.41	8.07	2.84	9.61	3.32	11.12	3.77	12.60	4.64	15.49	5.47	18.27
4½	2.20	7.35	2.73	9.12	3.25	10.87	3.77	12.59	4.28	14.28	5.27	17.59	6.22	20.79
5	2.45	8.19	3.04	10.17	3.63	12.13	4.21	14.06	4.77	15.96	5.89	19.69	6.98	23.31
5½	2.70	9.03	3.35	11.22	4.00	13.39	4.65	15.53	5.28	17.64	6.49	21.79	7.73	25.83
6	2.87	9.57	3.66	12.27	4.38	14.65	5.09	17.00	5.78	19.32	7.15	23.89	8.19	28.35

LENGTH AND TENSION OF CHAINS.

With Sines and Cosines of the Angles of Direction for given Deflections.

Rule.—For Tension—Multiply the total weight to be suspended by the factor opposite the deflection or versed sine of the Chains; the product is the total tension at the middle, or point of suspension, as may be required. The use of the other columns are obvious.

Angle at Point of Suspension.	Versed Sine or Deflection.	Length of Chain, Chord line being Unity.	Tension at the Middle weight suspended being Unity.	Tension at each point of Suspension. Weight suspended being Unity.	Sine of the Angle at Point of Suspension.	Cosine of Angle at Point of Suspension.
5..43	1-40th	..	4.995	5.200	0.0996	0.9950
11..19	1-20th	..	2.485	2.536	0.1962	0.9805
13..52	1-16.28	1.012	2.003	2.080	0.2396	0.9708
14..55	1-15th	1.015	1.877	1.943	0.2574	0.9663
15..57	1-14th	1.018	1.753	1.823	0.2747	0.9615
17..06	1-13th	1.020	1.625	1.700	0.2940	0.9558
18..33	1-12th	1.0246	1.490	1.572	0.3181	0.9480
19..59	1-11th	1.0288	1.373	1.463	0.3417	0.9398
21..48	1-10th	1.0349	1.252	1.349	0.3714	0.9285

GENERAL RULES FOR CATENARY CURVES.

To find angle of direction (x) of curve at point of suspension, when the chord line and versed sine are given?

$$\text{sine of } x = \frac{2 \text{ v. sine}}{\sqrt{(2 \text{ v. sine}^2 + \text{semichord}^2)}}$$

To find the tension at each point of suspension (T) when the angle of direction (x) at such points is given?

$$T = \frac{\text{Total weight suspended.}}{2 \text{ sine } x.}$$

To find the tension at the lowest point of the curve (t) when the angle of direction (x) at the point of suspension is given?

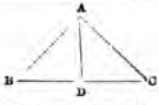
$$t = \frac{\frac{1}{2} \text{ the weight suspended} \times \text{cosine } x}{\text{sine } x.}$$

NOTE.—For an easy rule, although not precisely accurate, take—

$$t = \frac{\text{chord} \times \text{weight}}{8 \text{ v. sine}}$$

Horizontal pull on the points of suspension = T × *cosine* x; therefore if chains are unbalanced, this will represent the tendency to upset the towers; and if the chains pass back at an unequal angle, the difference of the cosines of the angles of direction is the measure of resistance on each.

Vertical pressure on the points of suspension = T × sine x. This pressure is additive in any case, for both sides of the point for the tension on the backstay must balance the main chains, the difference of pressure on each side is therefore only as the sine of the angle x.—*(Drewry, on S. Bridges.)*



STRAINS AND THRUSTS OF ROOFS,
BEAMS, OR LOCK GATES.

TABLE of the Proportional Tension or Compression of the various parts of a Truss, B A C, the rise or pitch being given. The Load at A being taken as unity for Weights, and the length B C as unity for the rise or pitch A D.

Rise or Pitch. A D	Angle of Pitch. A B D	Compression. A B	Tension. B C	Rise or Pitch. A D	Angle of Pitch. A D	Compression. A B	Tension. B C	Rise or Pitch. A D	Angle of Pitch. A B D	Compression. A B	Tension. B C
B. C.=1	Dg. Mn.	Wt=1.00	Wt=1.00	B. C.=1	Dg. Min.	Wt=1.00	Wt=1.00	B. C.=1	Dg. Min	Wt=1.00	Wt=1.00
.002	0. 14	.500004	125.00	.045	5. 08½	.5020	5.555	.150	16.42	.5220	1.667
.004	0. 27½	.500016	62.50	.047	5.22	.5022	5.319	.160	17.45	.5250	1.562
.005	0. 34½	.500025	50.00	.050	5.43	.5025	5.000	.170	18.47	.5281	1.470
.006	0.41	.500035	41.66	.053	6.03	.5028	4.717	.175	19. 17½	.5297	1.429
.008	0.55	.500064	31.25	.055	6.17	.5030	4.545	.180	19.48	.5314	1.389
.010	1.09	.500101	25.00	.057	6.30	.5032	4.386	.190	20. 48½	.5349	1.315
.012	1. 22½	.500144	20.83	.060	6. 50½	.5036	4.167	.200	21.48	.5385	1.250
.014	1.36	.500195	17.86	.065	7. 24½	.5042	3.846	.225	24.14	.5483	1.111
.016	1.50	.500256	15.62	.070	7. 58	.5049	3.571	.250	26.34	.5590	1.000
.018	2.04	.500325	13.89	.075	8.32	.5056	3.333	.275	28.49	.5707	.909
.020	2. 17½	.500400	12.50	.080	9. 05½	.5064	3.125	.300	30.58	.5831	.833
.022	2.31	.500483	11.36	.085	9.39	.5072	2.941	.350	34. 59½	.6103	.714
.025	2.52	.500626	10.00	.090	10.12	.5080	2. 778	.400	38.40	.6404	.625
.027	3. 05½	.500729	9.26	.095	10. 45½	.5089	2.631	.450	41.59	.6726	.555
.029	3.19	.500839	8.62	.100	11. 18½	.5099	2.500	.50	45.00	.7071	.500
.030	3.26	.500899	8.333	.105	11. 51½	.5109	2.381	.55	47.44	.7434	.454
.032	3.40	.501026	7.812	.110	12. 24½	.5120	2.272	.60	50.12	.7811	.417
.035	4.00	.501221	7.143	.120	13.30	.5142	2.083	.70	54.28	.8603	.357
.037	4.14	.501368	6.757	.125	14. 03	.5154	2.000	.75	56.19	.9015	.333
.040	4. 34½	.501598	6.250	.130	14. 34½	.5166	1.923	.80	58.00	.9435	.312
.042	4.48	.501760	6.952	.140	15.38	.5192	1.786	.87	60.00	1.0000	.287

STRAIN AND DIMENSIONS OF LOCK GATES,

TABLE of Transverse Strain from Pressure of Water, upon 3 feet depth of Surface, at stated heads; with the Dimensions of Square Oak Timber necessary to bear three times such strain; the Gates being placed at an angle of 19° 25′.

Length of Gate.	6 Feet.		8 Feet.		10 Feet.		12 Feet.		14 Feet.		16 Feet.		18 Feet.		20 Feet.	
	Strn. on 3 feet dpth. of surface.	Size to bear three times strain.	Strn. on 3 feet dpth. of surface.	Size to bear three times' strain.	Strn. on 3 feet dpth of surface.	Size to bear three times' strain.	Strn. on 3 feet dpth. of surface.	Size to bear three times' strain.	Strn. on 3 feet dpth of surface.	Size to bear three times' strain.	Strn. on 3 feet dpth. of surface.	Size to bear three times' strain.	Strn. on 3 feet dpth. of surface.	Size to bear three times' strain.	Strn. on 3 feet dpth. of surface.	Size to bear three times' strain.
Feet.	Tns.	Inche.	Tns.	Inches	Tns.	Inches	Tns.	Inches	Tns.	Inches	Tns.	Inches	Tns.	Inches	Tns.	Inches
6	1.9	5.49	2.5	6.05	3.2	6.05	3.8	6.92	4.5	7.29	5.1	7.62	5.7	7.93	6.4	8.21
7	2.2	6.09	2.9	6.70	3.7	7.22	4.4	7.67	5.2	8.07	5.9	8.45	6.7	8.78	7.4	9.10
8	2.5	6.66	3.4	7.32	4.2	7.89	5.1	8.39	5.9	8.83	6.8	9.23	7.6	9.60	8.5	9.94
9	2.8	7.20	3.8	7.92	4.8	8.54	5.7	9.07	6.7	9.55	7.6	9.98	8.6	10.38	9.6	10.75
10	3.2	7.72	4.2	8.50	5.3	9.16	6.4	9.73	7.4	10.24	8.5	10.71	9.6	11.14	10.6	11.54
11	3.5	8.23	4.6	9.06	5.8	9.76	7.0	10.37	8.2	10.92	9.3	11.41	10.5	11.87	11.7	12.30
12	3.8	8.72	5.1	9.60	6.4	10.34	7.6	10.98	8.9	11.57	10.2	12.10	11.5	12.58	12.8	13.03
13	4.1	9.20	5.5	10.12	6.9	10.90	8.3	11.59	9.7	12.20	11.0	12.76	12.4	13.27	13.8	13.74
14	4.4	9.67	5.9	10.64	7.4	11.46	8.9	12.18	10.4	12.82	11.9	13.40	13.4	13.94	14.9	14.44
15	4.8	10.12	6.4	11.14	8.0	12.00	9.6	12.75	11.2	13.42	12.8	14.03	14.4	14.55	16.0	15.12
16	5.1	10.56	6.8	11.63	8.5	12.53	10.2	13.31	11.9	14.01	13.6	14.65	15.3	15.24	17.0	15.78
17	5.4	11.00	7.2	12.11	9.0	13.05	10.8	13.86	12.6	14.60	14.5	15.26	16.3	15.86	18.1	16.43
18	5.7	11.43	7.6	12.58	9.6	13.55	11.5	14.40	13.4	15.16	15.3	15.85	17.2	16.48	19.2	17.07
19	6.0	11.85	8.1	13.04	10.1	14.04	12.1	14.93	14.1	15.72	16.2	16.43	18.2	17.09	20.2	17.70
20	6.4	12.26	8.5	13.49	10.6	14.54	12.8	15.45	14.9	16.26	17.0	17.00	19.2	17.68	21.3	18.31

CAST IRON BEAMS.—Table 31

TABLE OF SAFE LOAD,

IF EQUALLY DISTRIBUTED, EXPRESSED IN CWTS.

For Beams 6 to 16 Inches deep.

Rule.—Multiply the area which a proposed beam has to support, by the weight of the floor or bridge, and the greatest load, due to such area, all in cwts.; find the nearest corresponding number in the table, having the required depth and length, and the proper dimensions of the bottom Flange will be found at top of the column. The tables also give the safe weight to be borne by beams of any of the stated dimensions.

Note.—Floors should generally be reckoned to carry 2.5 cwts. per foot superficial, including their own weight.

Road Bridges " " " 5.0 cwts. " "

Railway Bridges " " " 10.0 cwts. " "

but for railway girders of cast iron, beyond 18 feet span, only half the tabular numbers should be used.

Beam 6 inches deep.

Dimensions of bottom Flange in inches.	4×1	5×1	6×1	8×1½	9×1½
Length, feet.	Cwts.	Cwts.	Cwts.	Cwts	Cwts.
5	133	166	200	333	391
6	111	139	166	277	326
8	83	104	125	208	244
10	66	83	100	166	195
12	55	69	83	138	163
14	47	59	71	119	140
16	41	52	62	104	122
18	37	46	55	92	108

Beam 8 inches deep.

4×1	5×1	6×1	8×1½	9×1½
Cwts.	Cwts.	Cwts.	Cwts.	Cwts.
177	222	266	444	521
148	185	222	370	435
111	139	166	277	325
89	111	133	222	260
74	92	111	185	217
63	79	95	159	187
55	69	83	138	163
49	62	74	123	144

Beam 10 inches deep.

Dimensions of bottom Flange in inches.	5×1	6×1	8×1½	9×1½	10×1½
Length, feet.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.
6	231	277	463	521	578
8	173	208	346	391	434
10	139	166	278	313	347
12	115	139	230	260	289
14	99	119	198	223	248
16	86	104	172	195	217
18	77	93	154	173	193
20	69	83	138	156	173

Beam 12 inches deep.

6×1	8×1½	9×1½	10×1½	11×1½
Cwts.	Cwts.	Cwts.	Cwts.	Cwts.
333	555	625	694	916
250	416	469	521	688
200	333	375	417	550
166	278	312	347	458
109	238	268	298	393
125	208	234	261	344
111	185	208	232	306
100	166	187	209	275

Beam 14 inches deep.

Dimensions of bottom Flange in inches.	8×1½	9×1½	10×1½	11×1½	12×1½
Length, feet.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.
8	486	547	607	802	875
10	389	438	486	642	700
12	324	365	405	535	584
14	278	313	347	459	501
16	243	274	304	401	437
18	216	244	270	357	389
20	195	219	243	321	350
22	177	199	221	291	318

Beam 16 inches deep.

8×1½	9×1½	10×1½	11×1½	12×1½
Cwts.	Cwts.	Cwts.	Cwts.	Cwts
555	625	694	916	1000
444	500	555	733	800
370	417	463	611	667
317	357	397	524	572
278	313	347	458	500
246	278	309	407	444
222	250	278	366	400
202	227	250	333	364

CAST IRON BEAMS.—TABLE 31

TABLE OF SAFE LOAD.

For Beams 18 to 30 inches deep.

Beam 18 inches deep.

Dimensions of bottom Flange in inches.	9×1¼	10×1¼	12×1¼	13×1¼	14×1¼
Length, feet.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.
10	562	625	900	975	1050
12	469	524	750	813	875
14	402	446	643	696	750
16	351	390	562	609	656
18	312	347	500	542	583
20	281	312	450	487	525
22	256	284	409	443	477
24	234	261	375	406	437

Beam 21 inches deep.

Dimensions of bottom Flange in inches.	10×1¼	12×1¼	14×1¼	15×1¼	16×1¼
Length, feet.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.
10	875	1050	1225	1312	1400
12	729	875	1021	1094	1167
14	625	750	875	937	1000
16	546	656	766	820	875
18	486	583	681	729	778
20	437	525	613	656	700
22	398	477	557	596	637
24	364	437	510	547	583

Beam 24 inches deep.

Dimensions of bottom Flange in inches.	10×1¼	12×1¼	14×1¼	15×1¼	16×1¼	16×2	17×1¼	17×2	18×1¼	18×2
Length, feet.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.
12	833	1000	1166	1250	1333	1778	1416	1819	1500	2000
14	714	857	1000	1071	1143	1524	1214	1560	1286	1714
16	623	750	875	937	1000	1333	1062	1365	1125	1500
18	555	666	777	833	889	1185	944	1213	1000	1333
20	500	600	700	750	800	1067	849	1092	900	1200
22	454	545	636	682	727	970	772	992	818	1091
24	416	500	583	625	666	889	708	910	750	1000
26	384	461	538	577	615	836	656	840	692	923
28	357	428	500	535	571	762	607	780	643	857
30	333	400	467	500	534	711	566	728	600	800

Beam 27 inches deep.

Dimensions of bottom Flange in inches.	12×1¼	14×1¼	14×2	15×1¼	15×2	16×1¼	16×2	17×1¼	17×2	18×2
Length, feet.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts	Cwts.
14	964	1125	1500	1205	1607	1286	1714	1366	1821	1928
18	740	863	1166	937	1249	1000	1333	1062	1416	1500
22	613	715	954	707	1022	818	1091	869	1159	1227
24	562	656	875	703	937	750	1000	797	1062	1125
28	482	562	750	603	803	643	857	683	911	964
30	450	525	700	562	750	600	800	637	850	900
32	422	492	656	527	702	562	750	598	797	843
34	397	463	618	496	661	530	706	562	750	794
36	375	437	583	469	625	500	666	531	708	750
40	337	388	525	421	563	450	600	478	638	675

Beam 30 inches deep.

Dimensions of bottom Flange in inches.	14×1¼	14×2	15×1¼	15×2	16×1¼	16×2	18×2	20×2	22×2	24×2
Length, feet.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.
18	972	1296	1041	1389	1111	1481	1666	1852	2038	2222
22	795	1060	852	1136	909	1212	1363	1515	1667	1818
24	714	952	781	1041	832	1111	1250	1388	1526	1664
28	612	816	669	892	714	952	1071	1190	1309	1428
30	571	761	625	833	679	889	1000	1111	1245	1358
32	536	715	586	780	624	833	937	1040	1144	1248
34	514	685	551	734	589	783	882	979	1080	1178
36	486	648	521	695	555	740	833	927	1019	1110
40	428	570	469	625	500	666	750	833	917	1000
44	397	529	426	568	454	606	681	757	833	908

ANGLES OF THE POINTS OF THE COMPASS WITH THE MERIDIAN.

Variation of magnetic needle 1850, latitude 51° =
Dip. " " " " =

North.	South.	Points.	Deg. Min.	North.	South.
		Add for ¼	2..48..45		
		" ½	5..37..30		
		" ¾	8..26..15		
N. by W.	S. by W.	1	11..15	N. by E.	S. by E.
N.N.W.	S.S.W.	2	22..30	N.N.E.	S.S.E.
N.W. by N.	S.W. by S.	3	33..45	N.E. by N.	S.E. by S.
N.W.	S.W.	4	45..00	N.E.	S.E.
N.W. by W.	S.W. by W.	5	56..15	N.E. by E.	S.E. by E.
W.N.W.	W.S.W.	6	67..30	E.N.E.	E.S.E.
W. by N.	W. by S.	7	78..45	E. by N.	E. by S.
West	West	8	90..00	East	East

MILES IN A DEGREE OF LONGITUDE AT EVERY DEGREE OF LATITUDE.

Degs. Lat.	Miles.	Degs. Lat.	Miles.	Degs. Lat.	Miles.	Degs. Lat.	Miles.	Degs. Lat.	Miles.	Degs. Lat.	Miles.
1	59.99	16	57.67	31	51.43	46	41.68	61	29.09	76	14.52
2	59.96	17	57.38	32	50.88	47	40.92	62	28.17	77	13.50
3	59.92	18	57.06	33	50.32	48	40.15	63	27.24	78	12.47
4	59.85	19	56.73	34	49.74	49	39.36	64	26.30	79	11.45
5	59.77	20	56.38	35	49.15	50	38.57	65	25.36	80	10.42
6	59.67	21	56.01	36	48.54	51	37.76	66	24.40	81	9.39
7	59.55	22	55.63	37	47.92	52	36.94	67	23.44	82	8.35
8	59.42	23	55.23	38	47.28	53	36.11	68	22.48	83	7.31
9	59.26	24	54.81	39	46.63	54	35.27	69	21.50	84	6.27
10	59.08	25	54.38	40	45.96	55	34.41	70	20.52	85	5.23
11	58.89	26	53.93	41	45.28	56	33.55	71	19.53	86	4.19
12	58.68	27	53.46	42	44.59	57	32.68	72	18.54	87	3.14
13	58.46	28	52.97	43	43.88	58	31.80	73	17.54	88	2.09
14	58.22	29	52.47	44	43.16	59	30.90	74	16.54	89	1.05
15	57.95	30	51.96	45	42.43	60	30.00	75	15.53	90	0.00

24856 miles	=	mean circumference of Earth.
7921 "	=	" diameter of Earth.
20921180 feet	=	radius of the Equator.
20853180 "	=	polar semi-axis.
60756.6	=	length of Geogr. or nautical mile.
1.15068 to 1	=	ratio of nautical to English mile.
39.01326 ins.	=	length of pendulum at the Equator.
39.11820 "	=	" at latitude 45.
39.1393 ins.	=	length of pendulum at London.
39.1555 "	=	" " Edinburgh.
32.1948 feet	=	force of gravity at London, in feet per second.
32.2041 "	=	" " Edinburgh " "
365.242245 days	=	tropical year.

Table 32a.
VELOCITY AND PRESSURE OF THE WIND.

Feet ℘ Min.	Miles ℘ Hour.	Force in lbs. on Sq. Foot.	DESCRIPTION.
88	1	.005	Hardly perceptible.
352	4	.079	Gentle wind and breezes.
440	5	0.123	
880	10	0.492	Good breeze.
1320	15	1.107	
1760	20	1.970	Brisk gale.
2640	30	4.429	High winds.
3080	35	6.027	
3520	40	7.870	Very high.
3960	45	9.960	
4400	50	12.300	Storm.
5280	60	16.710	Great storm.
7040	80	31.490	Hurricane.
8800	100	49.200	

TIDES occur twice in every 24 hours and 50½ minutes. When a place is on the same side of the Equator as the moon, the Tide which is produced, while the moon is *above* the horizon, is greater than while the moon is *under* the horizon of the place. When a place is on the opposite side of the Equator to the moon, the effect is reversed. In Midsummer, the afternoon Tides are higher than the morning Tides. In winter the morning Tides are highest.

Table 32b.
For finding the Height of Tide at any period after High Water.

Time from High Water. Hours.	Min.	Multiplier.
0	00	1.000
0	30	.975
1	00	.916
1	30	.841
2	00	.741
2	30	.625
3	00	.500
3	30	.375
4	00	.258
4	30	.158
5	00	.083
5	30	.025

Rule.—Multiply the range of Tide for the day by the Factor opposite the hour at which the height is required.

Example.—The total rise of Tide at Limehouse, on the 12th of April, was 20.4 feet; High Water made at 2 p.m: what was the height of Tide at 4 p.m.?

20.4×74=15.11 feet.

Table 32c.
SHOWING THE LENGTH IN FEET OF ONE MINUTE OF LONGITUDE AND LATITUDE,
Being One Nautic Mile.

Note.—To obtain the number of miles in a degree, at any latitude or longitude, multiply the tabular numbers by 60, and divide by 5280; thus, at the Equator, the length of a degree is 69.15 miles.

Latitude.	Minute of Longitude.	Minute of Latitude.	Latitude.	Minute of Longitude.	Minute of Latitude.	Latitude.	Minute of Longitude.	Minute of Latitude.
Deg.	Feet.	Feet.	Deg.	Feet.	Feet.	Deg.	Feet.	Feet.
0	6085.2	6085.20	35	4990.2	6105.0	53	3670.2	6124.8
2	6081.6		36	4920.0		54	3585.0	
4	6070.2		37	4866.0		55	3498.0	
6	6052.2		38	4801.2		56	3410.4	
8	6026.4		39	4735.2		57	3322.2	
10	5993.4		40	4668.0		58	3232.2	
12	5953.2	6087.78	41	4599.0	6111.6	59	3141.6	6130.1
14	4905.8		42	4528.8		60	3050.4	
16	5851.2		43	4457.4		61	2958.0	
18	5789.4		44	4384.2		62	2864.4	
20	5721.6		45	4309.8		63	2770.2	
22	5645.4		46	4234.2		64	2675.8	
24	5562.0	6095.22	47	4157.4	6118.2	65	2578.8	6135.6
26	5472.6		48	4079.4		66	2482.2	
28	5377.2		49	3999.6		67	2384.4	
30	5274.0		50	3919.2		68	2286.0	
32	5165.4		51	3837.0		69	2187.0	
34	5050.2		52	3754.2		70	2087.4	

MOUNTAIN BAROMETER.—TABLE 33

TABLE B.
Difference of Temperature.

Diff. of Temp.	Corrections.	Diff. of Temp.	Corrections.
Cent. degs.	feet.	Cent. degs.	feet.
0.5	2.46	10.5	50.69
1.0	4.92	11.0	53.15
1.5	7.21	11.5	55.44
2.0	9.51	12.0	57.74
2.5	11.97	12.5	60.20
3.0	14.43	13.0	62.66
3.5	16.89	13.5	65.12
4.0	19.35	14.0	67.58
4.5	21.81	14.5	70.04
5.0	24.27	15.0	72.50
5.5	26.57	15.5	74.80
6.0	28.87	16.0	77.10
6.5	31.33	16.5	79.56
7.0	33.79	17.0	82.02
7.5	36.25	17.5	84.48
8.0	38.71	18.0	86.94
8.5	41.00	18.5	89.40
9.0	43.30	19.0	91.86
9.5	45.76	19.5	94.32
10.0	48.22	20.0	96.78

Table A can be applied to any barometer, deducting the number for the temperature from the observations for heights.

Table B gives the amount to be *deducted* from the height, according to the difference of the attached thermometers—or to be *added*, if the upper station should be warmer than the lower. For correction due to expansion of air, &c. see "Rules."

Table C gives the amount to be added for gravity & centrifugal force.

TABLE A.
For reduction to Freezing Point.

Temp.	Corrections for the Barometer at			
	27 Inches.	28 Inches.	29 Inches.	30 Inches.
Fah. degs.	inch.	inch.	inch.	inch.
32	.0086	.0088	.0091	.0094
34	.0134	.0138	.0143	.0148
36	.0183	.0188	.0194	.0201
38	.0231	.0238	.0246	.0255
40	.0279	.0288	.0298	.0309
42	.0327	.0338	.0350	.0362
44	.0375	.0388	.0402	.0416
46	.0423	.0438	.0454	.0470
48	.0471	.0488	.0506	.0523
50	.0519	.0538	.0558	.0577
52	.0568	.0588	.0609	.0630
54	.0616	.0638	.0661	.0684
56	.0664	.0688	.0713	.0738
58	.0712	.0738	.0765	.0791
60	.0760	.0788	.0817	.0845
62	.0809	.0838	.0868	.0898
64	.0857	.0888	.0920	.0951
66	.0906	.0938	.0971	.1005
68	.0954	.0988	.1023	.1058
70	.1000	.1037	.1075	.1112
72	.1049	.1087	.1126	.1165
74	.1097	.1137	.1178	.1218
76	.1146	.1187	.1229	.1272
78	.1194	.1237	.1281	.1325
80	.1241	.1286	.1332	.1378
82	.1289	.1336	.1384	.1432
84	.1338	.1386	.1435	.1485
86	.1385	.1435	.1486	.1538
88	.1433	.1485	.1538	.1591
90	.1482	.1535	.1589	.1644

TABLE C.
Gravity and Centrifugal force.
CORRECTIONS TO BE ADDED.

Latitude.	to 10°	15°	20°	25°	30°	35°	40°	45°	50°	55°
Approx. height. feet.	feet.	feet	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.
600	3.9	3.3	3.3	3.3	2.6	2.6	1.9	1.9	1.9	1.3
1300	7.9	7.2	6.5	6.5	5.9	5.6	4.6	3.9	3 3	2.6
2000	11.1	10.5	9.8	9.2	8.5	7.9	6.5	5.9	5.2	3.9
2600	14.7	14.1	14.0	12.4	11.5	10.2	6.2	7.8	6.5	5.5
3300	20.1	17.5	17.3	15.7	14.1	12.4	11.1	10.1	8.5	7.2
4000	22.9	20.9	19.7	19.0	16.7	15.1	13.7	11.8	10.1	8.5
4600	26.9	24.9	23.3	22.0	20.0	17.7	15.7	13.7	11.8	9.8
5300	30.2	28.9	26.9	24.9	22.9	20.3	18.3	15.7	14.0	11.1
5900	34.1	32.1	30.8	38.2	26.2	22.9	20.6	17.7	15.1	12.4
6600	37.7	36.1	34.1	31.5	28.9	25.7	22.9	19.7	17.3	13.7

Table D.

TABLE OF THE ELASTIC FORCE OF AQUEOUS VAPOUR,

WITH THE WEIGHT, IN GRAINS TROY, OF A CUBIC FOOT,

At the following Temperatures of the Dew Point, in Degrees Fahrenheit.

Temp. of Dew Point.	Force of Aqueous Vapour.	Weight in Grns. Troy of Cub. Ft. of Vapour.	Temp. of Dew Point.	Force of Aqueous Vapour.	Weight in Grns. Troy of Cub. Ft. of Vapour.	Temp. of Dew Point.	Force of Aqueous Vapour.	Weight in Grns. Troy of Cub. Ft. of Vapour.
Fah.	Inches.	Grains.	Fah.	Inches.	Grains.	Fah.	Inches.	Grains.
5°	.074	0.93	31°	0.192	2.29	51°	.386	4.42
10	.089	1.11	32	.199	2.37	52	.400	4.56
12	.096	1.19	33	.207	2.45	53	.414	4.71
14	.104	1.28	34	.214	2.53	54	.428	4.86
15	.108	1.32	35	.222	2.62	55	.442	5.02
16	.112	1.37	36	.230	2.71	56	.458	5.18
17	.116	1.41	37	.238	2.80	57	.473	5.34
18	.120	1.47	38	.246	2.89	58	.489	5.51
19	.125	1.52	39	.255	2.99	59	.506	5.69
20	.129	1.58	40	.264	3.09	60	.523	5.87
21	.134	1.63	41	.274	3.19	62	.559	6.25
22	.139	1.69	42	.283	3.30	64	.597	6.65
23	.144	1.75	43	.293	3.41	66	.638	7.08
24	.150	1.81	44	.304	3.52	68	.681	7.53
25	.155	1.87	45	.315	3.64	70	.727	8.00
26	.161	1.93	46	.326	3.76	72	.776	8.50
27	.167	2.00	47	.337	3.88	74	.827	9.04
28	.173	2.07	48	.349	4.01	76	.882	9.60
29	.179	2.14	49	.361	4.14	78	.940	10.19
30	.186	2.21	50	.373	4.28	80	1.001	10.81

Table F.

CORRECTIONS,

To be added to the Mercurial Column for Capillary Attraction.

Diam. of Tube.	Correction	Diam. of Tube.	Correction
Inch.	Inch.	Inch.	Inch.
.10	.140	.30	.029
.12	.113	.35	.021
.14	.094	.40	.015
.16	.079	.45	.011
.18	.068	.50	.008
.20	.058	.55	.006
.25	.041	.60	.004

Note.—This correction is practically unnecessary, excepting for scientific reduction of observations.

Mountain Barometers, when varying in size, when used for simultaneous observations, should have their comparative errors determined by inspection.

Rule for Table D.

This Table shows the amount to be deducted from the mercurial column, to obtain the true pressure of dry air; the dew point having been previously computed by Table E, from observations of the ordinary dry and wet bulb thermometer.

Example.

The Barometer stands at 29.275
When the dew-point, by calculation, is 16.2°, the pressure = ... .117

True pressure of air = 29.158

Table E.

DRY AND WET BULB THERMOMETERS.

Factors for deducing the Dew Point from the Temperature of Evaporation.

Readings of the Dry Bulb Thermometer. Fah.	Factor.
Between 28° and 29°	5.7
,, 29 ,, 30	5.0
,, 30 ,, 31	4.6
,, 31 ,, 32	3.6
,, 32 ,, 33	3.1
,, 33 ,, 34	2.8
,, 34 ,, 35	2.6
,, 35 ,, 40	2.4
,, 40 ,, 45	2.3
,, 45 ,, 50	2.2
,, 50 ,, 55	2.1
,, 55 ,, 60	1.9
,, 60 ,, 70	1.8
,, 70 ,, 80	1.7

Rule for Table E.

Multiply the difference between the two thermometers by the *factor* corresponding to the temperature of the dry bulb thermometer; the product, subtracted from the latter, gives the temperature of the dew point.

Example.

Dry bulb thermometer = 66°
Wet bulb thermometer = 57

Difference..... = 9
Factor for 66° .. = 1.8

Product.... =16.2

66°—16.2° = 49.8° temp. of dew point.

AREA AND CIRCUMFERENCE OF CIRCLES.

Diameters. 1 to 43.

The Square Root of any Area is the side of an equivalent Square.

Diam.	Area.	Circum.	Diam.	Area.	Circum.	Diam.	Area.	Circum.
			13.25	137.88	41.62	28.25	626.79	88.75
			13.5	143.14	42.41	28.5	637.94	89.53
.1	0.007	.31	13.75	148.49	43.19	28.75	649.18	90.32
.2	0.031	.62	14.	153.94	43.98	29.	660.51	91.10
.3	0.070	.94	14.25	159.48	44.77	29.25	671.95	91.89
.4	0.125	1.26	14.5	165.13	45.55	29.5	683.49	92.67
.5	0.196	1.57	14.75	170.87	46.34	29.75	695.12	93.46
.6	0.282	1.88	15.	176.71	47.12	30.	706.85	94.24
.7	0.384	2.20	15.25	182.65	47.90	30.25	718.68	95.03
.8	0.502	2.51	15.5	188.69	48.69	30.5	730.61	95.81
.9	0.636	2.82	15.75	194.82	49.48	30.75	742.64	96.60
1.00	.7854	3.1416	**16.**	201.06	50.26	**31.**	754.76	97.38
1.25	1.22	3.92	16.25	207.39	51.05	31.25	766.99	98.17
1.5	1.76	4.71	16.5	213.82	51.83	31.5	779.31	98.96
1.75	2.40	5.49	16.75	220.35	52.62	31.75	791.73	99.74
2.	3.14	6.28	17.	226.98	53.40	32.	804.24	100.53
2.25	3.97	7.06	17.25	233.70	54.19	32.25	816.86	101.31
2.5	4.90	7.85	17.5	240.52	54.97	32.5	829.57	102.10
2.75	5.93	8.63	17.75	247.44	55.76	32.75	842.38	102.88
3.	7.06	9.42	**18.**	254.47	56.54	**33.**	855.29	103.67
3.25	8.29	10.21	18.25	266.58	57.33	33.25	868.30	104.45
3.5	9.62	10.99	18.5	268.80	58.11	33.5	881.41	105.24
3.75	11.04	11.78	18.75	276.11	58.90	33.75	894.61	106.02
4.	12.56	12.56	19.	283.53	59.69	34.	907.92	106.81
4.25	14.18	13.35	19.25	291.04	60.47	34.25	921.32	107.59
4.5	15.90	14.14	19.5	298.64	61.26	34.5	934.82	108.38
4.75	17.72	14.92	19.75	306.35	62.04	34.75	948.41	109.17
5.	19.63	15.70	**20.**	314.16	62.83	**35.**	962.11	109.95
5.25	21.65	16.49	20.25	322.06	63.61	35.25	975.90	110.74
5.5	23.76	17.28	20.5	330.06	64.40	35.5	989.79	111.52
5.75	25.97	18.06	20.75	338.16	65.18	35.75	1003.78	112.31
6.	28.27	18.85	21.	346.36	65.97	36.	1017.87	113.09
6.25	30.68	19.63	21.25	354.65	66.75	36.25	1032.06	113.88
6.5	33.18	20.42	21.5	363.05	67.54	36.5	1046.34	114.66
6.75	35.78	21.20	21.75	371.54	68.32	36.75	1060.73	115.45
7.	38.48	21.99	**22.**	380.13	69.11	**37.**	1075.21	116.23
7.25	41.28	22.77	22.25	388.82	69.90	37.25	1089.79	117.02
7.5	44.17	23.56	22.5	397.60	70.68	37.5	1104.46	117.80
7.75	47.17	24.34	22.75	406.49	71.47	37.75	1119.24	118.59
8.	50.26	25.13	23.	415.47	72.25	38.	1134.11	119.38
8.25	53.45	25.92	23.25	424.55	73.04	38.25	1149.08	120.16
8.5	56.74	26.70	23.5	433.73	73.82	38.5	1164.15	120.95
8.75	60.13	27.49	23.75	443.01	74.61	38.75	1179.32	121.73
9.	63.62	28.27	**24.**	452.39	75.39	**39.**	1194.59	122.52
9.25	67.20	29.06	24.25	461.86	76.18	39.25	1209.95	123.30
9.5	70.88	29.84	24.5	471.43	76.96	39.5	1225.41	124.09
9.75	74.66	30.63	24.75	481.10	77.75	39.75	1240.97	124.87
10.	78.54	31.42	25.	490.87	78.53	40.	1256.63	125.66
10.25	82.52	32.20	25.25	500.74	79.32	40.25	1272.39	126.44
10.5	86.59	32.98	25.5	510.70	80.11	40.5	1288.24	127.23
10.75	90.76	33.77	25.75	520.76	80.89	40.75	1304.20	128.01
11.	95.03	34.55	**26.**	530.93	81.68	**41.**	1320.25	128.80
11.25	99.40	35.34	26.25	541.18	82.46	41.25	1336.40	129.59
11.5	103.87	36.13	26.5	551.54	83.25	41.5	1352.65	130.37
11.75	108.43	36.91	26.75	562.00	84.03	41.75	1368.99	131.16
12.	113.09	37.69	27.	572.55	84.82	42.	1385.44	131.94
12.25	117.86	38.48	27.25	583.20	85.60	42.25	1401.98	132.73
12.5	122.72	39.27	27.5	593.95	86.39	42.5	1418.62	133.51
12.75	127.67	40.05	27.75	604.80	87.17	42.75	1435.36	134.30
13.	132.73	40.84	**28.**	615.75	87.96	**43.**	1452.20	135.08

AREA AND CIRCUMFERENCE OF CIRCLES.

Diameters 43.25 to 100.

The Square Root of any Area is the side of an equivalent Square.

Diam.	Area.	Circum.	Diam.	Area.	Circum.	Diam.	Area.	Circum.
43.25	1469.13	135.87	58.25	2664.90	182.99	73.25	4214.10	230.12
43.5	1486.16	136.65	58.5	2687.82	183.78	73.5	4242.91	230.90
43.75	1503.30	137.44	58.75	2710.85	184.56	73.75	4271.82	231.69
44.	1520.53	138.23	59.	2733.97	185.35	74.	4300.84	232.47
44.25	1537.85	139.01	59.25	2757.18	186.13	74.25	4329.94	233.26
44.5	1556.28	139.80	59.5	2780.50	186.92	74.5	4359.15	234.04
44.75	1572.80	140.58	59.75	2803.92	187.71	74.75	4388.46	234.83
45.	1590.43	141.37	60.	2827.43	188.49	75.	4417.86	235.61
45.25	1608.15	142.15	60.25	2851.04	189.28	75.25	4447.36	236.40
45.5	1625.97	142.94	60.5	2874.75	190.06	75.5	4476.96	237.19
45.75	1643.88	143.72	60.75	2898.56	190.85	75.75	4506.66	237.97
46.	1661.90	144.51	**61.**	2922.46	191.63	**76.**	4536.45	238.76
46.25	1680.01	145.29	61.25	2946.47	192.42	76.5	4596.34	240.33
46.5	1698.22	146.08	61.5	2970.57	193.20	77.	4656.62	241.90
46.75	1716.53	146.86	61.75	2894.77	193.99	77.5	4717.29	243.47
47.	1734.94	147.65	62.	3019.07	194.77	78.	4778.36	245.04
47.25	1753.45	148.44	62.25	3043.46	195.56	78.5	4839.81	246.61
47.5	1772.05	149.22	62.5	3067.96	196.34	79.	4901.66	248.18
47.75	1790.75	150.01	62.75	3092.55	197.13	79.5	4963.91	249.75
48.	1809.55	150.79	**63.**	3117.24	197.92	**80.**	5026.54	251.32
48.25	1828.45	151.58	63.25	3142.03	198.70	80.5	5089.57	252.89
48.5	1847.45	152.36	63.5	3166.92	199.49	81.	5152.99	254.46
48.75	1866.54	153.15	63.75	3191.90	200.27	81.5	5216.81	256.03
49.	1885.74	153.93	64.	3216.99	201.06	82.	5281.01	257.61
49.25	1905.83	154.72	64.25	3242.17	201.84	82.5	5345.61	259.18
49.5	1924.42	155.50	64.5	3267.45	202.63	83.	5410.60	260.75
49.75	1943.90	156.29	64.75	3292.83	203.41	83.5	5475.99	262.32
50.	1963.49	157.07	**65.**	3318.30	204.20	**84.**	5541.76	263.89
50.25	1983.17	157.96	65.25	3343.88	204.98	84.5	5607.93	265.46
50.5	2002.96	158.65	65.5	3369.55	205.77	85.	5674.50	267.03
50.75	2022.84	159.43	65.75	3395.32	206.55	85.5	5741.45	268.60
51.	2042.82	160.22	66.	3421.19	207.34	86.	5808.80	270.17
51.25	2062.89	161.00	66.25	3447.16	208.13	86.5	5876.54	271.74
51.5	2083.07	161.79	66.5	3473.22	208.91	87.	5944.67	273.31
51.75	2103.34	162.57	66.75	3499.39	209.70	87.5	6013.20	274.88
52.	2123.71	163.36	**67.**	3525.65	210.48	**88.**	6082.12	276.46
52.25	2144.18	164.14	67.25	3552.01	211.27	88.5	6151.43	278.03
52.5	2164.75	164.93	67.5	3578.47	212.05	89.	6221.13	279.60
52.75	2185.41	165.71	67.75	3605.02	212.84	89.5	6291.23	281.17
53.	2206.18	166.50	68.	3631.68	213.62	90.	6361.72	282.74
53.25	2227.04	167.28	68.25	3658.43	214.41	90.5	6432.60	284.31
53.5	2248.00	168.07	68.5	3685.28	215.19	91.	6503.88	285.88
53.75	2269.06	168.86	68.75	3712.23	215.98	91.5	6575.54	287.45
54.	2290.22	169.64	**69.**	3739.28	216.76	**92.**	6647.61	289.02
54.25	2311.47	170.43	69.25	3766.42	217.55	92.5	6720.06	290.59
54.5	2332.82	171.21	69.5	3793.66	218.34	93.	6792.90	292.16
54.75	2354.28	172.00	69.75	3821.01	219.12	93.5	6866.14	293.73
55.	2375.82	172.78	70.	3848.45	219.91	94.	6939.77	295.30
55.25	2397.47	173.57	70.25	3875.99	220.69	94.5	7013.80	296.88
55.5	2419.22	174.35	70.5	3903.62	221.48	95.	7088.21	298.45
55.75	2441.06	175.14	70.75	3931.36	222.27	95.5	7163.02	300.02
56.	2463.00	175.92	**71.**	3959.19	223.05	**96.**	7238.22	301.59
56.25	2485.04	176.71	71.25	3987.12	223.84	96.5	7313.82	303.16
56.5	2507.18	177.49	71.5	4015.15	224.62	97.	7389.81	304.73
56.75	2520.42	178.28	71.75	4043.28	225.41	97.5	7466.19	306.30
57.	2551.75	179.07	72.	4071.50	226.19	98.	7542.96	307.87
57.25	2574.19	179.85	72.25	4099.83	226.98	98.5	7620.12	309.44
57.5	2596.72	180.64	72.5	4128.24	227.76	99.	7697.68	311.01
57.75	2619.35	181.42	72.75	4156.77	228.55	99.5	7775.63	312.58
58.	2642.07	182.21	**73.**	4185.38	229.33	**100.**	7853.98	314.15

SQUARES, CUBES, SQUARE ROOTS, CUBE ROOTS, FIFTH POWERS AND RECIPROCALS.

From 1 to 50.

Num.	Squares.	Cubes.	Sq. Roots.	Cube Roots	Fifth Power.	Reciprocals.
1	1	1	1.000	1.000	1	.100000000
2	4	8	1.414	1.260	32	.500000000
3	9	27	1.732	1.442	243	.333333333
4	16	64	2.000	1.587	1024	.250000000
5	25	125	2.236	1.710	3125	.200000000
6	36	216	2.449	1.817	7776	.166666667
7	49	343	2.645	1.913	16807	.142857143
8	64	512	2.828	2.000	32768	.125000000
9	81	729	3.000	2.080	59049	.111111111
10	**100**	**1000**	**3.162**	**2.154**	**100000**	**.100000000**
11	121	1331	3.316	2.223	161051	.090909091
12	144	1728	3.464	2.289	248832	.083333333
13	169	2197	3.605	2.351	371293	.076923077
14	196	2744	3.741	2.410	537824	.071428571
15	225	3375	3.873	2.466	759375	.066666667
16	256	4096	4.000	2.520	1048576	.062500000
17	289	4913	4.123	2.571	1419857	.058823529
18	324	5832	4.242	2.620	1889568	.055555556
19	361	6859	4.359	2.668	2476099	.052631579
20	**400**	**8000**	**4.472**	**2.714**	**3200000**	**.050000000**
21	441	9261	4.582	2.759	4084101	.047619048
22	484	10648	4.690	2.802	5153632	.045454545
23	529	12167	4.796	2.844	6436343	.043478261
24	576	13824	4.899	2.884	7962624	.041666667
25	625	15625	5.000	2.924	9765625	.040000000
26	676	17576	5.099	2.962	11881376	.038461538
27	729	19683	5.196	3.000	14348907	.037037037
28	784	21952	5.291	3.036	17210368	.035714286
29	841	24389	5.385	3.072	20511149	.034482759
30	**900**	**27000**	**5.477**	**3.107**	**24300000**	**.033333333**
31	961	29791	5.567	3.141	28629151	.032258065
32	1024	32768	5.657	3.175	33554432	.031250000
33	1089	35937	5.744	3.207	39135393	.030303030
34	1156	39304	5.831	3.239	45435424	.029411765
35	1225	42875	5.916	3.271	52521875	.028571429
36	1296	46656	6.000	3.302	60466176	.027777778
37	1369	50653	6.082	3.332	69343957	.027027027
38	1444	54872	6.164	3.362	79235168	.026315789
39	1521	59319	6.245	3.391	90224199	.025641026
40	**1600**	**64000**	**6.324**	**3.420**	**102400000**	**.025000000**
41	1681	68921	6.403	3.448	115856201	.024390244
42	1764	74088	6.480	3.476	130691232	.023809524
43	1849	79507	6.557	3.503	147008443	.023255814
44	1936	85184	6.633	3.530	164916224	.022727273
45	2025	91125	6.708	3.557	184528125	.022222222
46	2116	97336	6.782	3.583	205962976	.021739130
47	2209	103823	6.855	3.609	229345007	.021276600
48	2304	110592	6.928	3.634	254803968	.020833333
49	2401	117649	7.000	3.659	282475249	.020408163
50	**2500**	**125000**	**7.071**	**3.684**	**312500000**	**.020000000**

POWERS AND ROOTS.—TABLE 35

SQUARES, CUBES, SQUARE ROOTS, CUBE ROOTS, FIFTH POWERS AND RECIPROCALS.

From 51 to 100.

Num.	Squares.	Cubes.	Sq. Roots.	CubeRoots	Fifth Power.	Reciprocals.
51	2601	132651	7.141	3.708	345025251	.019607843
52	2704	140608	7.211	3.732	380204032	.019230769
53	2809	148877	7.280	3.756	418195493	.018867925
54	2916	157464	7.348	3.780	459165024	.018518519
55	3025	166375	7.416	3.803	503284375	.018181818
56	3136	175616	7.483	3.826	550731776	.017857143
57	3249	185193	7.549	3.848	601692057	.017543860
58	3364	195112	7.615	3.871	656356768	.017241379
59	3481	205379	7.681	3.893	714924299	.016949153
60	**3600**	**216000**	**7.745**	**3.915**	**777600000**	**.016666667**
61	3721	226981	7.810	3.936	844596301	.016393443
62	3844	238328	7.874	3.958	916132832	.016129032
63	3969	250047	7.937	3.979	992436543	.015873016
64	4096	262144	8.000	4.000	1073741824	.015625000
65	4225	274625	8.062	4.021	1160290625	.015384615
66	4356	287496	8.124	4.041	1252332576	.015151515
67	4489	300763	8.185	4.061	1350125107	.014925373
68	4624	314432	8.246	4.081	1453933568	.014705882
69	4761	328509	8.306	4.101	1564031349	.014492754
70	**4900**	**343000**	**8.366**	**4.121**	**1680700000**	**.014285714**
71	5041	357911	8.426	4.141	1804229351	.014084507
72	5184	373248	8.485	4.160	1934917632	.013888889
73	5329	389017	8.544	4.179	2073071593	.013698630
74	5476	405224	8.602	4.198	2219006624	.013513514
75	5625	421875	8.660	4.217	2373046875	.013333333
76	5776	438976	8.718	4.236	2535525376	.013157895
77	5929	456533	8.775	4.254	2706784157	.012987013
78	6084	474552	8.831	4.272	2887174368	.012820513
79	6241	493039	8.888	4.291	3077056399	.012658228
80	**6400**	**512000**	**8.944**	**4.309**	**3276800000**	**.012500000**
81	6561	531441	9.000	4.326	3486784401	.012345679
82	6724	551368	9.055	4.344	3707398432	.012195122
83	6889	571787	9.110	4.362	3939040643	.012048193
84	7056	592704	9.165	4.379	4182119424	.011904762
85	7225	614125	9.219	4.397	4437053125	.011764706
86	7396	636056	9.273	4.414	4704270176	.011627907
87	7569	658503	9.327	4.431	4984209207	.011494253
88	7744	681472	9.381	4.447	5277319168	.011363636
89	7921	704969	9.434	4.464	5584059449	.011235955
90	**8100**	**729000**	**9.487**	**4.481**	**5904900000**	**.011111111**
91	8281	753571	9.539	4.498	6240321451	.010989011
92	8464	778688	9.591	4.514	6590815232	.010869565
93	8649	804357	9.643	4.530	6956883693	.010752688
94	8836	830584	9.695	4.547	7339040224	.010638298
95	9025	857375	9.746	4.563	7737809375	.010526316
96	9216	884736	9.798	4.579	8153726976	.010416667
97	9409	912673	9.849	4.594	8587340257	.010309278
98	9604	941192	9.899	4.610	9039207968	.010204082
99	9801	970299	9.950	4.626	9509900499	.010101010
100	**10000**	**100000**	**10000**	**4.641**	**10000000000**	**.010000000**

SQUARES, SQUARE ROOTS, AND CUBE ROOTS.

From 101 to 200.

Num.	Squares.	Square Roots	Cube Roots.	Num.	Squares.	Square Roots	Cube Roots
101	10201	10.050	4.657	151	22801	12.288	5.325
102	10404	10.099	4.672	152	23104	12.329	5.337
103	10609	10.149	4.687	153	23409	12.369	5.348
104	10816	10.198	4.702	154	23716	12.409	5.360
105	11025	10.247	4.717	155	24025	12.450	5.371
106	11236	10.295	4.732	156	24336	12.490	5.383
107	11449	10.344	4.747	157	24649	12.530	5.394
108	11664	10.392	4.762	158	24964	12.570	5.406
109	11881	10.440	4.777	159	25281	12.609	5.417
110	**12100**	**10.488**	**4.791**	**160**	**25600**	**12.649**	**5.429**
111	12321	10.535	4.806	161	25921	12.688	5.440
112	12544	10.583	4.820	162	26244	12.728	5.451
113	12769	10.630	4.834	163	26569	12.767	5.462
114	12996	10.677	4.849	164	26896	12.806	5.474
115	13225	10.724	4.863	165	27225	12.845	5.485
116	13456	10.770	4.877	166	27556	12.884	5.496
117	13689	10.816	4.891	167	27889	12.923	5.507
118	13924	10.863	4.905	168	28224	12.961	5.518
119	14161	10.909	4.918	169	28561	13.000	5.528
120	**14400**	**10.954**	**4.932**	**170**	**28900**	**13.038**	**5.539**
121	14641	11.000	4.946	171	29241	13.076	5.550
122	14884	11.045	4.959	172	29584	13.115	5.561
123	15129	11.090	4.973	173	29929	13.153	5.572
124	15376	11.135	4.986	174	30276	13.191	5.583
125	15625	11.180	5.000	175	30625	13.229	5.593
126	15876	11.225	5.013	176	30976	13.266	5.604
127	16129	11.269	5.026	177	31329	13.304	5.614
128	16384	11.313	5.039	178	31684	13.341	5.625
129	16641	11.358	5.052	179	32041	13.379	5.636
130	**16900**	**11.402**	**5.065**	**180**	**32.400**	**13.416**	**5.646**
131	17161	11.445	5.078	181	32761	13.453	5.656
132	17424	11.489	5.091	182	33124	13.490	5.667
133	17689	11.532	5.104	183	33489	13.527	5.677
134	17956	11.576	5.117	184	33856	13.564	5.688
135	18225	11.619	5.130	185	34225	13.601	5.698
136	18496	11.662	5.142	186	34596	13.638	5.708
137	18769	11.704	5.155	187	34969	13.675	5.718
138	19044	11.747	5.167	188	35344	13.711	5.728
139	19321	11.790	5.180	189	35721	13.747	5.739
140	**19600**	**11.832**	**5.192**	**190**	**36.100**	**13.784**	**5.749**
141	19881	11.874	5.204	191	36481	13 820	5.759
142	20164	11.916	5.217	192	36864	13.856	5.769
143	20449	11.958	5.229	193	37249	13.892	5.779
144	20736	12.000	5.241	194	37636	13.928	5.789
145	21025	12.041	5.253	195	38025	13.964	5.799
146	21316	12.083	5.265	196	38416	14.000	5.809
147	21609	12.124	5.277	197	38809	14.035	5.818
148	21904	12.165	5.289	198	39204	14.071	5.828
149	22201	12.206	5.301	199	39601	14.107	5.838
150	**22500**	**12.247**	**5.313**	**200**	**40000**	**14.142**	**5.848**

SQUARES, SQUARE ROOTS, AND CUBE ROOTS.

From 201 to 300.

Num.	Squares.	Square Roots	Cube Roots.	Num.	Squares.	Square Roots	Cube Roots.
201	40401	14.177	5.858	251	63001	15.843	6.308
202	40804	14.212	5.867	252	63504	15.874	6.316
203	41209	14.248	5.877	253	64009	15.906	6.325
204	41616	14.283	5.887	254	64516	15.937	6.333
205	42025	14.318	5.896	255	65025	15.969	6.341
206	42436	14.353	5.906	256	65536	16.000	6.349
207	42849	14.387	5.915	257	66049	16.031	6.358
208	43264	14.422	5.925	258	66564	16.062	6.366
209	43681	14.456	5.934	259	67081	16.093	6.374
210	**44100**	**14.491**	**5.943**	**260**	**67600**	**16.124**	**6.382**
211	44521	14.526	5.953	261	68121	16.155	6.390
212	44944	14.560	5.962	262	68644	16.186	6.399
213	45369	14.594	5.972	263	69169	16.217	6.407
214	45796	14.629	5.981	264	69696	16.248	6.415
215	46225	14.662	5.991	265	70225	16.279	6.423
216	46656	14.697	6.000	266	70756	16.309	6.431
217	47089	14.731	6.009	267	71289	16.340	6.439
218	47524	14.765	6.018	268	71824	16.371	6.447
219	47961	14.798	6.027	269	72361	16.401	6.455
220	**48400**	**14.832**	**6.037**	**270**	**72900**	**16.431**	**6.463**
221	48841	14.866	6.045	271	73441	16.462	6.471
222	49284	14.899	6.055	272	73984	16.492	6.479
223	49729	14.933	6.064	273	74529	16.522	6.487
224	50176	14.966	6.073	274	75076	16.552	6.495
225	50625	15.000	6.082	275	75625	16.583	6.503
226	51076	15.033	6.091	276	76176	16.613	6.511
227	51529	15.066	6.100	277	76729	16.643	6.518
228	51984	15.099	6.109	278	77284	16.678	6.526
229	52441	15.133	6.118	279	77841	16.703	6.534
230	**52900**	**15.166**	**6.126**	**280**	**78400**	**16.733**	**6.542**
231	53361	15.198	6.135	281	78961	16.763	6 550
232	53824	15.231	6.144	282	79524	16.793	6.557
233	54289	15.264	6.153	283	80089	16.822	6.565
234	54756	15.297	6.162	284	80656	16.852	6.573
235	55225	15.330	6.171	285	81225	16.882	6.581
236	55696	15.362	6.179	286	81796	16.911	6.588
237	56169	15.395	6.188	287	82369	16.941	6.596
238	56644	15.427	6.197	288	82944	16.970	6.604
239	57121	15.459	6.205	289	83521	17.000	6.611
240	**57600**	**15.492**	**6.214**	**290**	**84100**	**1.7029**	**6.619**
241	58081	15.524	6.223	291	84681	17.058	6.627
242	58564	15.556	6.231	292	85264	17.088	6.634
243	59049	15.588	6.240	293	85849	17.117	6.642
244	59536	15.620	6.249	294	86436	17.146	6.649
245	60025	15.652	6.257	295	87025	17.175	6.657
246	60516	15.684	6.266	296	87616	17.204	6.664
247	61009	15.716	6.274	297	88209	17.233	6.672
248	61504	15.748	6.283	298	88804	17.262	6.679
249	62001	15.780	6.291	299	89401	17.291	6.687
250	**62500**	**15.811**	**6.299**	**300**	**90000**	**17320**	**6.694**

SQUARES, SQUARE ROOTS, AND CUBE ROOTS.

From 301 to 400.

Num.	Squares.	Square Roots	Cube Roots.	Num.	Squares.	Square Roots	Cube Roots
301	90601	17.349	6.702	351	123201	18.735	7.054
302	91204	17.378	6.709	352	123904	18.761	7.060
303	91809	17.407	6.716	353	124609	18.788	7.067
304	92416	17.435	6.724	354	125316	18.815	7.074
305	93025	17.464	6.731	355	126025	18.841	7.080
306	93636	17.493	6.738	356	126736	18.868	7.087
307	94249	17.521	6.746	357	127449	18.894	7.094
308	94864	17.550	6.753	358	128164	18.921	7.100
309	95481	17.578	6.760	359	128881	18.947	7.107
310	**96100**	**17.607**	**6.786**	**360**	**129600**	**18.973**	**7.114**
311	96721	17.635	6.775	361	130321	19.000	7.120
312	97344	17.663	6.782	362	131044	19.026	7.127
313	97969	17.692	6.789	363	131769	19.052	7.133
314	98596	17.720	6.797	364	132496	19.078	7.140
315	99225	17.748	6.804	365	133225	19.105	7.146
316	99856	17.776	6.811	366	133956	19.131	7.153
317	100489	17.804	6.818	367	134689	19.157	7.159
318	101124	17.832	6.825	368	135424	19.183	7.166
319	101761	17.860	6.833	369	136161	19.209	7.172
320	**102400**	**17.888**	**6.840**	**370**	**136900**	**19.235**	**7.179**
321	103041	17.916	6.847	371	137641	19.261	7.185
322	103684	17.944	6.854	372	138384	19.287	7.192
323	104329	17.972	6.861	373	139129	19.313	7.198
324	104976	18.000	6.868	374	139876	19.339	7.205
325	105625	18.028	6.875	375	140625	19.365	7.211
326	106276	18.055	6.882	376	141376	19.391	7.217
327	106929	18.083	6.889	377	142129	19.416	7.224
328	107584	18.111	6.896	378	142884	19.442	7.230
329	108241	18.138	6.903	379	143641	19.468	7.237
330	**108900**	**18.166**	**6.910**	**380**	**144400**	**19.493**	**7.243**
331	109561	18.193	6.917	381	145161	19.519	7.249
332	110224	18.221	6.924	382	145924	19.545	7.256
333	110889	18.248	6.931	383	146689	19.570	7.262
334	111556	18.275	6.938	384	147456	19.596	7.268
335	112225	18.303	6.945	385	148225	19.621	7.275
336	112896	18.330	6.952	386	148996	19.649	7.281
337	113569	18.357	6.959	387	149769	19.672	7.287
338	114244	18.385	6.966	388	150544	19.698	7.293
339	114921	18.412	6.972	389	151321	19.723	7.300
340	**115600**	**18.439**	**6.979**	**390**	**152100**	**19.748**	**7.306**
341	116281	18.466	6.986	391	152881	19.774	7.312
342	116964	18.493	6.993	392	153664	19.799	7.318
343	117649	18.520	7.000	393	154449	19.824	7.325
344	118336	18.547	7.007	394	155236	19.849	7.331
345	119025	18.574	7.013	395	156025	19.874	7.337
346	119716	18.601	7.020	396	156816	19.900	7.343
347	120409	18.628	7.027	397	157609	19.925	7.349
348	121104	18.655	7.034	398	158404	19.950	7.356
349	121801	18.681	7.040	399	159201	19.975	7.362
350	**122500**	**18.708**	**7.047**	**400**	**160000**	**20.000**	**7.358**

SQUARES, SQUARE ROOTS, AND CUBE ROOTS.

From 401 to 500

Num.	Squares.	Square Roots	Cube Roots.	Num.	Squares.	Square Roots	Cube Roots.
401	160801	20.025	7.374	451	203401	21.236	7.669
402	161604	20.050	7.380	452	204304	21.260	7.674
403	162409	20.075	7.386	453	205209	21.284	7.680
404	163216	20.100	7.392	454	206116	21 307	7.686
405	164025	20.124	7.398	455	207025	21.331	7.691
406	164836	20.149	7.405	456	207936	21.354	7.697
407	165649	20.174	7.411	457	208849	21.377	7.702
408	166464	20.199	7.417	458	209764	21.401	7.708
409	167281	20.224	7.423	459	210681	21.424	7.719
410	**168100**	**20.248**	**7.429**	**460**	**211600**	**21.447**	**7.719**
411	168921	20.273	7.435	461	212521	21.471	7.725
412	169744	20.298	7.441	462	213444	21.494	7.730
413	170569	20.322	7.447	463	214369	21.517	7.736
414	171396	20.347	7.453	464	215296	21.540	7.742
415	172225	20.371	7.459	465	216225	21.564	7.747
416	173056	20.396	7.465	466	217156	21.587	7.753
417	173889	20.420	7.471	467	218089	21.610	7.758
418	174724	20.445	7.477	468	219024	21.633	7.764
419	175561	20.469	7.483	469	219961	21.656	7.769
420	**176400**	**20.494**	**7.489**	**470**	**220900**	**21.679**	**7.775**
421	177241	20.518	7.495	471	221841	21.702	7.780
422	178084	20.542	7.501	472	222784	21.725	7.786
423	178929	20.567	7.506	473	223729	21.748	7.791
424	179776	20.591	7.512	474	224676	21.771	7.797
425	180625	20.615	7.518	475	225625	21.794	7.802
426	181476	20.640	7.524	476	226576	21.817	7.808
427	182329	20.664	7.530	477	227529	21.840	7.813
428	183184	20.688	7.536	478	228484	21.863	7.819
429	184041	20.712	7.542	479	229441	21.886	7.824
430	**184900**	**20.736**	**7.548**	**480**	**230400**	**21.909**	**7.830**
431	185761	20.760	7.553	481	231361	21.932	7.835
432	186624	20.784	7.559	482	232324	21.954	7.840
433	187489	20.808	7.565	483	233289	21.977	7.846
434	188356	20.832	7.571	484	234256	22.000	7.851
435	189225	20.856	7.577	485	235225	22.023	7.857
436	190096	20.880	7.583	486	236196	22.045	7.862
437	190969	20.904	7.588	487	237169	22.068	7.867
438	191844	20.928	7.594	488	238144	22.091	7.873
439	192721	20.952	7.600	489	239121	22.113	7.878
440	**193600**	**20.976**	**7.606**	**490**	**240100**	**22.136**	**7.884**
441	194481	21.000	7.611	491	241081	22.158	7.889
442	195364	21.024	7.617	492	242064	22.181	7.894
443	196249	21.047	7.623	493	243049	22.203	7.900
444	197136	21.071	7.629	494	244036	22.226	7.905
445	198025	21.095	7.634	495	245025	22.248	7.910
446	198916	21.119	7.640	496	246016	22.271	7.916
447	199809	21.142	7.646	497	247009	22.293	7.921
448	200704	21.166	7.652	498	248004	22.316	2.926
449	201601	21.189	7.657	499	249001	22.338	7.932
450	**202500**	**21.213**	**7.663**	**500**	**250000**	**22.360**	**7.937**

SQUARES, SQUARE ROOTS, AND CUBE ROOTS.

From 501 to 600

Num.	Squares.	SquareRoots	Cube Roots.	Num.	Squares.	Square Roots	Cube Roots.
501	251001	22.383	7.942	551	303601	23.473	8.198
502	252004	22.405	7.947	552	304704	23.494	8.203
503	253009	22.427	7.953	553	305809	23.516	8.208
504	254016	22.450	7.958	554	306916	23.537	8.213
505	255025	22.472	7.963	555	308025	23.558	8.218
506	256036	22.494	7.968	556	309136	23.579	8.223
507	257049	22.516	7.974	557	310249	23.601	8.228
508	258064	22.539	7.979	558	311364	23.622	8.233
509	259081	22.561	7.984	559	312481	23.643	8.237
510	**260100**	**22.583**	**7.989**	**560**	**313600**	**23.664**	**8.242**
511	261121	22.605	7.995	561	314721	23.685	8.247
512	262144	22.627	8.000	562	315844	23.706	8.252
513	263169	22.649	8.005	563	316969	23.727	8.257
514	264196	22.671	8.010	564	318096	23.748	8.262
515	265225	22.693	8.015	565	319225	23.770	8.267
516	266256	22.715	8.021	566	320356	23.791	8.272
517	267289	22.737	8.026	567	321489	23.812	8.277
518	268324	22.759	8.031	568	322624	23.833	8.281
519	269361	22.781	8.036	569	323761	23.854	8.286
520	**270400**	**22.803**	**8.041**	**570**	**324900**	**23.874**	**8.291**
521	271411	22.825	8.046	571	326041	23.895	8.296
522	272484	22.847	8.052	572	327184	23.916	8.301
523	273529	22.869	8.057	573	328329	23.937	8.306
524	274576	22.891	8.062	574	329476	23.958	8.310
525	275625	22.913	8.067	575	330625	23.979	8.315
526	276676	22.934	8.072	576	331776	24.000	8.320
527	277729	22.956	8.077	577	332929	24.021	8.325
528	278784	22.978	8.082	578	334084	24.041	8.330
529	279841	23.000	8.087	579	335241	24.062	8.335
530	**280900**	**23.022**	**8.092**	**580**	**336400**	**24.083**	**8.339**
531	281961	23.043	8.098	581	337561	24.104	8.344
532	283024	23.065	8.103	582	338724	24.124	8.349
533	284089	23.087	8.108	583	339889	24.145	8.354
534	285156	23.108	8.113	584	341056	24.166	8.358
535	286225	23.130	8.118	585	342225	24.187	8.363
536	287296	23.151	8.123	586	343396	24.207	8.368
537	288369	23.173	8.128	587	344569	24.228	8.373
538	289444	23.195	8.133	588	345744	24.249	8.378
539	290521	23.216	8.138	589	346921	24.269	8.382
540	**291600**	**23.238**	**8.143**	**590**	**348100**	**24.290**	**8.387**
541	292681	23.259	8.148	591	349281	24.310	8.392
542	293764	23.281	8.153	592	350464	24.331	8.396
543	294849	23.302	8.158	593	351649	24.351	8.401
544	295936	23.324	8.163	594	352836	24.372	8.406
545	297025	23.345	8.168	595	354025	24.392	8.411
546	298116	23.366	8.173	596	355216	24.413	8.415
547	299209	23.388	8.178	597	356409	24.433	8.420
548	300304	23.409	8.183	598	357604	24.454	8.425
549	301401	23.431	8.188	599	358801	24.474	8.429
550	**302500**	**23.452**	**8.193**	**600**	**360000**	**24.495**	**8.434**

SQUARES, SQUARE ROOTS, AND CUBE ROOTS.

From 601 to 700

Num.	Squares.	SquareRoots	Cube Roots.	Num.	Squares.	SquareRoots	Cube Roots.
601	361201	24.515	8.439	651	423801	25.515	8.667
602	362404	24.535	8.443	652	425104	25.534	8.671
603	363609	24.556	8.448	653	426409	25.554	8.675
604	364816	24.576	8.453	654	427716	25.573	8.680
605	366025	24.597	8.457	655	429025	25.593	8.684
606	367236	24.617	8.462	656	430336	25.612	8.689
607	368449	24.637	8.467	657	431639	25.632	8.693
608	369664	24.657	8.471	658	432964	25.651	8.698
609	370881	24.678	8.476	659	434281	25.671	8.702
610	**372100**	**24.698**	**8.481**	**660**	**435600**	**25.690**	**8.706**
611	373321	24.718	8.485	661	436921	25.720	8.711
612	374544	24.738	8.490	662	438244	25.729	8.715
613	375769	24.759	8.495	663	439569	25.749	8.720
614	376996	24.779	8.499	664	440896	25.768	8.724
615	378225	24.799	8.504	665	442225	25.787	8.728
616	379456	24.819	8 508	666	443556	25.807	8.733
617	380689	24.839	8.513	667	444899	25.826	8.737
618	381924	24.859	8.518	668	446224	25.845	8.741
619	383161	24.880	8.522	669	447561	25.865	8.746
620	**384400**	**24.900**	**8.527**	**670**	**448900**	**25.884**	**8.750**
621	385641	24.920	8.531	671	450241	25.903	8.754
622	386884	24.940	8.536	672	451584	25.923	8.759
623	388129	24.960	8.541	673	452929	25.942	8.763
624	389376	24.980	8.545	674	454276	25.961	8.768
625	390625	25.000	8.550	675	455625	25.981	8.772
626	391876	25.020	8.554	676	456976	26.000	8.776
627	393129	25.040	8.559	677	458329	26.019	8.781
628	394384	25.060	8.563	678	459684	26.038	8.785
629	395641	25.080	8.568	679	461041	26.057	8.789
630	**396900**	**25.100**	**8.572**	**680**	**462400**	**26.077**	**8.793**
631	398161	25.120	8.577	681	463761	26.096	8.798
632	399424	25.140	8.581	682	465124	26.115	8.802
633	400689	25.159	8.586	683	466489	26.134	8.806
634	401956	25.179	8.591	684	467856	26.153	8.811
635	403225	25.199	8.595	685	469225	26.172	8.815
636	404496	25.219	8.600	686	470596	26.191	8.819
637	405769	25.239	8.604	687	471969	26.210	8.824
638	407044	25.258	8.609	688	473344	26.230	8.828
639	408321	25.278	8.613	689	474721	26.249	88.32
640	**409600**	**25.298**	**8.618**	**690**	**476100**	**26.268**	**8.836**
641	410881	25.318	8.622	691	477481	26.287	8.841
642	412164	25 338	8.627	692	478864	26.306	8.845
643	413449	25.357	8.631	693	480249	26.325	8.849
644	414736	25.377	8.635	694	481636	26.344	8.853
645	416125	25.397	8.640	695	483025	26.363	8.858
646	417316	25.416	8.644	696	484416	26.382	8.862
647	418609	25.436	8.649	697	485809	26.401	8.866
648	419904	25.456	8.653	698	487204	26.419	8.870
649	421201	25.475	8.658	699	488601	26.438	8.875
650	**422500**	**25.495**	**8.662**	**700**	**490.000**	**26.457**	**8.879**

SQUARES, SQUARE ROOTS, AND CUBE ROOTS.

From 701 to 800.

Num.	Squares.	Square Roots	Cube Roots.	Num.	Squares.	Square Roots	Cube Roots.
701	491401	26.476	8.883	751	564001	27.404	9.089
702	492804	26.495	8.887	752	565504	27.422	9.093
703	494209	26.514	8.891	753	567000	27.441	9.098
704	495616	26.533	8.896	754	568516	27.459	9.102
705	497025	26.552	8.900	755	570025	27.477	9.106
706	498436	26.570	8.904	756	571536	27.495	9.110
707	499849	26.589	8.908	757	573049	27.513	9.114
708	501264	26.608	8.913	758	574564	27.532	9.118
709	502681	26.627	8.917	759	576081	27.550	9.122
710	**504100**	**26.646**	**8.921**	**760**	**577600**	**27.568**	**9.126**
711	505521	26.664	8.925	761	579121	27.586	9.130
712	506944	26.683	8.929	762	580644	27.604	9.134
713	508369	26.702	8.933	763	582169	27.622	9.138
714	509796	26.721	8.938	764	583696	27.640	9.142
715	511225	26.739	8.942	765	585225	27.658	9.146
716	512656	26.758	8.946	766	586756	27.677	9.150
717	514089	26.777	8.950	767	588289	27.695	9.154
718	515524	26.795	8.954	768	589824	27.713	9.158
719	516961	26.814	8.958	769	591361	27.731	9.161
720	**518400**	**26.833**	**8.963**	**770**	**592900**	**27.749**	**9.165**
721	519841	26.851	8.967	771	594441	27.767	9.169
722	521284	26.870	8.971	772	595984	27.785	9.173
723	522729	26.888	8.975	773	597529	27.803	9.177
724	524176	26.907	8.979	774	599076	27.821	9.181
725	525625	26.926	8.983	775	600625	27.839	9.185
726	527076	26.944	8.987	776	602176	27.857	9.189
727	528529	26.963	8.992	777	603729	27.875	9.193
728	529984	26.981	8.996	778	605284	27.892	9.197
729	531441	27.000	9.000	779	606841	27.910	9.201
730	**532900**	**27.018**	**9.004**	**780**	**608400**	**27.928**	**9.205**
731	534361	27.037	9.008	781	609961	27.946	9 209
732	535824	27.055	9.012	782	611524	27.964	9.213
733	537289	27.074	9.016	783	613089	27.982	9.217
734	538756	27.092	9.020	784	614656	28.000	9.221
735	540225	27.111	9.024	785	616225	28.018	9.225
736	541696	27.129	9.029	786	617796	28.035	9.229
737	543169	27.148	9.033	787	619369	28.053	9.232
738	544644	27.166	9.037	788	620944	28.071	9.236
739	546121	27.184	9.041	789	622521	28.089	9.240
740	**547600**	**27.203**	**9.045**	**790**	**624100**	**28.107**	**9.244**
741	549801	27.221	9.049	791	625681	28.125	9.248
742	550564	27.239	9.053	792	627624	28.142	9.252
743	552049	27.258	9.057	793	628849	28.160	9.256
744	553536	27.276	9.061	794	630436	28.178	9.260
745	555025	27.294	9.065	795	632025	28.196	9.264
746	556516	27.313	9.069	796	633616	28.213	9.267
747	558009	27.331	9.073	797	635209	28.231	9.271
748	559504	27.349	9.077	798	636804	28.247	9.275
749	561001	27.368	9.081	799	638401	28.266	9.279
750	**562500**	**27.386**	**9.085**	**800**	**640000**	**28.284**	**9.283**

SQUARES, SQUARE ROOTS, AND CUBE ROOTS.

From 801 to 900

Num.	Squares.	Square Roots	Cube Roots	Num.	Squares.	Square Roots	Cube Roots
801	641601	28.302	9.287	851	724201	29.172	9.476
802	643204	28.319	9.291	852	725904	29.189	9.480
803	644809	28.337	9.295	853	727609	29.206	9.484
804	646416	28.355	9.298	854	729316	29.223	9.487
805	648025	28.372	9.302	855	731025	29.240	9.491
806	649636	28.390	9.306	856	732736	29.257	9.495
807	651249	28.408	9.310	857	734449	29.274	9.498
808	652864	28.425	9.314	858	736164	29.291	9.502
809	654481	28.443	9.318	859	737881	29.309	9.506
810	**656100**	**28.460**	**9.321**	**860**	**739600**	**29.326**	**9.509**
811	657721	28.478	9.325	861	741321	29.343	9.513
812	659344	28.495	9.329	862	743044	29.360	9.517
813	660969	28.513	9.333	863	744769	29.377	9.521
814	662596	28.530	9.337	864	746496	29.394	9.524
815	664225	28.548	9.341	865	748225	29.411	9.528
816	665856	28.566	9.344	866	749956	29.428	9.532
817	667489	28.583	9.348	867	751689	29.445	9.535
818	669124	28.600	9.352	868	753424	29.462	9.539
819	670761	28.618	9.356	869	755161	29.479	9.543
820	**672400**	**28.635**	**9.360**	**870**	**756900**	**29.496**	**9.546**
821	674041	28.653	9.364	871	758641	29.513	9.550
822	675684	28.670	9.367	872	760384	29.529	9.554
823	677329	28.688	9.371	873	762129	29.546	9.557
824	678976	28.705	9.375	874	763876	29.563	9.561
825	680625	28.723	9.379	875	765625	29.580	9.564
826	682276	28.740	9.382	876	767376	29.597	9.568
827	683929	28.757	9.386	877	769129	29.614	9.572
828	685584	28.775	9.390	878	770884	29.631	9.575
829	687241	28.792	9.394	879	772641	29.648	9.579
830	**688900**	**28.810**	**9.398**	**880**	**774400**	**29.665**	**9.583**
831	690561	28.827	9.401	881	776161	29.681	9.586
832	692224	28.844	9.405	882	777924	29.698	9.590
833	693889	28.862	9.409	883	779689	29.715	9.594
834	695556	28.879	9.413	884	781456	29.732	9.597
835	697225	28.896	9.416	885	783225	29.749	9.601
836	698896	28.913	9.420	886	784996	29.766	9.604
837	700569	28.931	9.424	887	786769	29.782	9.608
838	702244	28.948	9.428	888	788544	29.799	9.612
839	703921	28.965	9.431	889	790321	29.816	9.615
840	**705600**	**28.983**	**9.435**	**890**	**792100**	**29.833**	**9.619**
841	707281	29.000	9.439	891	793881	29.849	9.622
842	708964	29.017	9.443	892	795664	29.866	9.626
843	710649	29.034	9.446	893	797449	29.883	9.630
844	712336	29.051	9.450	894	799236	29.900	9.633
845	714025	29.069	9.454	895	801025	29.916	9.637
846	715716	29.086	9.458	896	802816	29.933	9.640
847	717409	29.103	9.461	897	804609	29.950	9.644
848	719104	29.120	9.465	898	806404	29.966	9.648
849	720801	29.137	9.469	899	808201	29.983	9.651
850	**722500**	**29.155**	**9.472**	**900**	**810000**	**30.000**	**9.655**

SQUARES, SQUARE ROOTS, AND CUBE ROOTS.

From 901 to 1,000.

Num.	Squares.	SquareRoots	Cube Roots.	Num.	Squares.	SquareRoots	Cube Roots.
901	811801	30.017	9.658	951	904401	30.838	9.834
902	813604	30.033	9.662	952	906304	30.854	9.837
903	815409	30.050	9.666	953	908209	30.870	9.841
904	817216	30.066	9.669	954	910116	30.887	9.844
905	819025	30.083	9.672	955	912025	30.903	9.847
906	820836	30.100	9.676	956	913936	30.919	9.851
907	822649	30.116	9.680	957	915849	30.935	9.854
908	824464	30.133	9.683	958	917764	30.951	9.858
909	826281	30.150	9.687	959	919681	30 968	9.861
910	**828100**	**30.166**	**9.690**	**960**	**921600**	**30.984**	**9.865**
911	829921	30.183	9.694	961	923521	31.000	9.868
912	831744	20.199	9.697	962	925444	31.016	9.871
913	833569	30.216	9.701	963	927369	31.032	9.875
914	835396	30.232	9.705	964	929296	31.048	9.878
915	837225	30.249	9.708	965	931225	31.064	9.882
916	839056	30.265	9 712	966	933156	31.080	9.885
917	840889	30.282	7.715	967	935089	31.096	9.889
918	842724	30.298	9.719	968	937024	31.112	9.892
919	844561	30.315	9.722	969	938961	31.129	9.895
920	**846400**	**30.331**	**9.726**	**970**	**940900**	**31.145**	**9.899**
921	848241	30.348	9.729	971	942841	31.161	9.902
922	850084	30.364	9.733	972	944784	31.177	9.906
923	851929	30.381	9.736	973	946729	31.193	9.909
924	853776	30.397	9.740	974	948676	31.209	9.912
925	855625	30.414	9.743	975	950625	31.225	9.916
926	857476	30.430	9.747	976	952576	31.241	9.919
927	859329	30.446	9.750	977	954529	31.257	9.923
928	861184	30.463	9.754	978	956484	31.273	9.926
929	863041	30.479	9.757	979	958441	31.289	9.929
930	**864900**	**30.496**	**9.761**	**980**	**960400**	**31.305**	**9.933**
931	866761	30.512	9.764	981	962361	31.321	9.936
932	868624	30.528	9.768	982	964324	31.337	9.939
933	870489	30.545	9.771	983	966289	31.353	9.943
934	872356	30.561	9.775	984	968256	31.369	9.946
935	874225	30.578	9.778	985	970225	31.385	9.950
936	876096	30 594	9.782	986	972196	31.400	9.953
937	877969	30.610	9.785	987	974169	31.416	9.956
938	879844	30.627	9.789	988	976144	31.432	9.960
939	881721	30.643	9.792	989	978121	31.448	9.963
940	**883600**	**30.659**	**9.796**	**990**	**980100**	**31.464**	**9.966**
941	885481	30.676	9.799	991	982081	31.480	9.970
942	887364	30.692	9.803	992	984064	31.496	9.973
943	889249	30.708	9.806	993	986049	31.512	9.976
944	891136	30.724	9.810	994	988036	31.528	9.980
945	893025	30.741	9.813	995	990025	31.543	9.983
946	894916	30.757	9.816	996	992016	31.559	9.986
947	896809	30.773	9.820	997	994009	31.575	9.990
948	898704	30.789	9.823	998	996004	31.591	9.993
949	900601	30.806	9.827	999	998001	31.607	9.996
950	**902500**	**30.822**	**9.830**	**1000**	**1000000**	**31.623**	**10.000**

SQUARES, SQUARE ROOTS, AND CUBE ROOTS.

From 1,001 to 1,100.

Num.	Squares.	SquareRoots	Cube Roots	Num.	Squares.	SquareRoots	Cube Roots.
1001	1002001	31.638	10.003	1051	1104601	32 419	10.167
1002	1004004	31.654	10.006	1052	1106704	32.434	10.170
1003	1006009	31.670	10.010	1053	1108809	32.450	10.173
1004	1008016	31.686	10.013	1054	1110916	32.465	10.176
1005	1010025	31.702	10.016	1055	1113025	32.481	10.180
1006	1012036	31.717	10.020	1056	1115136	32.496	10.183
1007	1014049	31.733	10.023	1057	1117249	32.511	10 186
1008	1016064	31.749	10.026	1058	1119364	32.527	10.190
1009	1018081	31.765	10.030	1059	1121481	32.542	10.193
1010	**1020100**	**31.780**	**10.033**	**1060**	**1123600**	**32.558**	**10.196**
1011	1022121	31.796	10.036	1061	1125721	32.573	10.199
1012	1024144	31.812	10.039	1062	1127844	32.588	10.202
1013	1026169	31.828	10.043	1063	1129969	32.603	10.205
1014	1028196	31.843	10.046	1064	1132096	32.619	10.209
1015	1030225	31.859	10.050	1065	1134225	32.634	10.212
1016	1032256	31.875	10.053	1066	1136356	32.650	10.215
1017	1034289	31 890	10.056	1067	1138489	32.665	10.218
1018	1036324	31.906	10.059	1068	1140624	32.680	10.221
1019	1038361	31.922	10.063	1069	1142761	32.696	10.225
1020	**1040400**	**31.937**	**10.066**	**1070**	**1144900**	**32.711**	**10.228**
1021	1042441	31.953	10.069	1071	1147041	32.726	10.231
1022	1044484	31.969	10.073	1072	1149184	32.741	10.234
1023	1046529	31.984	10.076	1073	1151329	32.757	10.237
1024	1048576	32.000	10.079	1074	1153476	32.772	10.240
1025	1050625	32.016	10.082	1075	1155625	32.787	10.244
1026	1052676	32.031	10.086	1076	1157776	32.802	10.247
1027	1054729	32.047	10.089	1077	1159929	32.818	10.250
1028	1056784	32.062	10.092	1078	1162084	32.833	10.253
1029	1058841	32.078	10.096	1079	1164241	32.848	10.257
1030	**1060900**	**32.094**	**10.099**	**1080**	**1166400**	**32.863**	**10.260**
1031	1062961	32.109	10.102	1081	1168561	32.879	10.263
1032	1065024	32.125	10.105	1082	1170724	32.894	10.266
1033	1067089	32.140	10.109	1083	1172889	32.909	10.269
1034	1069156	32.156	10.112	1084	1175056	32.924	10.272
1035	1071225	32.171	10.115	1085	1177225	32.939	10.276
1036	1073296	32.187	10.118	1086	1179396	32.954	10.279
1037	1075369	32.202	10.121	1087	1181569	32.970	10.282
1038	1077444	32.218	10.125	1088	1183744	32.985	10.285
1039	1079521	32.233	10.128	1089	1185921	33.000	10.288
1040	**1081600**	**32.249**	**10.131**	**1090**	**1188100**	**33.015**	**10.291**
1041	1083681	32.264	10.134	1091	1190281	33.030	10.295
1042	1085764	32.280	10.138	1092	1192464	33.045	10.298
1043	1087849	32.295	10.141	1093	1194649	33.061	10.301
1044	1089936	32.311	10.144	1094	1196836	33.076	10.304
1045	1092025	32.326	10.148	1095	1199025	33.091	10.307
1046	1094116	32.342	10.151	1096	1201216	33.106	10.310
1047	1096209	32.357	10.154	1097	1203409	33.121	10.313
1048	1098304	32.373	10.157	1098	1205604	33.136	10.317
1049	1100401	32.388	10.160	1099	1207801	33.151	10.320
1050	**1102500**	**32.404**	**10.164**	**1100**	**1210000**	**33.166**	**10.323**

No. 100, Log. 2.000000 to No. 249, Log. 2.396199

No.	Log.	Diff.	No.	Log.	Diff.	No.	Log.	Diff.
100	000000	432	150	176091	289	200	301030	217
101	004321	428	151	178977	287	201	303196	216
102	008600	424	152	181844	285	202	305351	215
103	012837	420	153	184691	283	203	307496	213
104	017033	416	154	187521	281	204	309630	212
105	021189	412	155	190332	279	205	311754	211
106	025306	408	156	193125	278	206	313867	210
107	029384	404	157	195900	276	207	315970	209
108	033424	400	158	198657	274	208	318063	208
109	037426	397	159	201397	272	209	320146	207
110	041393	393	160	204120	271	210	322219	206
111	045323	389	161	206826	269	211	324282	205
112	049218	386	162	209515	267	212	326336	204
113	053078	383	163	212188	266	213	328380	203
114	056905	379	164	214844	264	214	330414	202
115	060698	376	165	217484	262	215	332438	202
116	064458	373	166	220108	261	216	334454	201
117	068186	370	167	222716	259	217	336460	199
118	071882	366	168	225309	258	218	338456	199
119	075547	363	169	227887	256	219	340444	198
120	079181	360	170	230449	255	220	342423	197
121	082785	357	171	232996	253	221	344392	196
122	086360	355	172	235528	252	222	346353	195
123	089905	352	173	238046	250	223	348305	194
124	093422	349	174	240549	249	224	350248	193
125	096910	346	175	243038	248	225	352183	193
126	100371	343	176	245513	246	226	354108	192
127	103804	341	177	247973	245	227	356026	191
128	107210	338	178	250420	243	228	357935	190
129	110590	335	179	252853	242	229	359835	189
130	113943	333	180	255273	241	230	361728	188
131	117271	330	181	257679	239	231	363612	188
132	120574	328	182	260071	238	232	365488	187
133	123852	325	183	262451	237	233	367356	186
134	127105	323	184	264818	235	234	369216	185
135	130334	321	185	267172	234	235	371068	184
136	133539	318	186	269513	233	236	372912	184
137	136721	316	187	271842	232	237	374748	183
138	139879	314	188	274158	230	238	376577	182
139	143015	311	189	276462	229	239	378398	181
140	146128	309	190	278754	228	240	380211	181
141	149219	307	191	281033	227	241	382017	180
142	152288	305	192	283301	226	242	383815	179
143	155336	303	193	285557	225	243	385606	178
144	158362	301	194	287802	223	244	387390	178
145	161368	299	195	290035	222	245	389166	177
146	164353	296	196	292256	221	246	390935	176
147	167317	295	197	294466	220	247	392697	176
148	170262	292	198	296665	219	248	394452	175
149	173186	291	199	298853	218	249	396199	174

The Logs. in the Table are decimals; the Index is one less than the figures of the number; the Log., therefore, in the Table, stands for any number—thus, Log. of 12 = 1.079181 Log. of 120 = 2.079181 Log. of 1200 = 3.079181.

No. 250, Log. 2.379940 to No. 399, Log. 2.600973

No.	Log.	Diff.	No.	Log.	Diff.	No.	Log.	Diff.
250	397940	173	300	477121	145	350	544068	124
251	399674	173	301	478566	144	351	545307	124
252	401401	172	302	480007	144	352	546543	123
253	403121	171	303	481443	143	353	547775	123
254	404834	171	304	482874	143	354	549003	123
255	406540	170	305	484300	142	355	550228	122
256	408240	169	306	485721	142	356	551450	122
257	409933	169	307	487138	141	357	552668	121
258	411620	168	308	488551	141	358	553883	121
259	413300	167	309	489958	140	359	555094	121
260	414973	167	310	491362	140	360	556303	120
261	416641	166	311	492760	139	361	557507	120
262	418301	165	312	494155	139	362	558709	120
263	419956	165	313	495544	139	363	559907	119
264	421604	164	314	496930	138	364	561101	119
265	423246	164	315	498311	138	365	562293	119
266	424882	163	316	499687	137	366	563481	119
267	426511	162	317	501095	137	367	564666	118
268	428135	162	318	502427	136	368	565848	118
269	429752	161	319	503791	136	369	567026	118
270	431364	161	320	505150	136	370	568202	117
271	432969	160	321	506505	135	371	569374	117
272	434569	159	322	507856	135	372	570543	117
273	436163	159	323	509203	134	373	571709	116
274	437751	158	324	510545	134	374	572872	116
275	439333	158	325	511883	133	375	574031	116
276	440909	157	326	513218	133	376	575188	115
277	442480	157	327	514548	132	377	576341	115
278	444045	156	328	515874	132	378	577492	115
279	445604	155	329	517196	132	379	578639	114
280	447158	155	330	518514	131	380	579784	114
281	448706	154	331	519828	131	381	580925	114
282	450249	154	332	521138	131	382	582063	114
283	451786	153	333	522444	130	383	583199	113
284	453318	153	334	523746	130	384	584331	113
285	454845	152	335	525045	129	385	585461	113
286	456366	152	336	526339	129	386	586587	112
287	457882	151	337	527630	129	387	587711	112
288	459392	151	338	528917	128	388	588832	112
289	460898	150	339	530200	128	389	589950	112
290	462398	140	340	531479	128	390	591065	111
291	463893	149	341	532754	127	391	592177	111
292	465383	149	342	534026	127	392	593286	111
293	466868	148	343	535294	126	393	594393	110
294	468347	148	344	536558	126	394	595496	110
295	469822	147	345	537819	126	395	596597	110
296	471292	146	346	539076	125	396	597695	110
297	472756	146	347	540329	125	397	598791	109
298	474216	146	348	541579	125	398	599883	109
299	475671	145	349	542825	124	399	600973	109

No. 400, Log. 2.602060 to No. 549, Log. 2.739572

No.	Log.	Diff.	No.	Log.	Diff.	No.	Log.	Diff.
400	602060	108	450	653213	96	500	698970	87
401	603144	108	451	654177	96	501	699838	87
402	604226	108	452	655138	96	502	700704	86
403	605305	108	453	656098	96	503	701568	86
404	606381	107	454	657056	96	504	702431	86
405	607455	107	455	658011	95	505	703291	86
406	608526	107	456	658965	95	506	704151	86
407	609594	107	457	659916	95	507	705008	86
408	610660	106	458	660865	95	508	705864	85
409	611723	106	459	661813	95	509	706718	85
410	612784	106	460	662758	94	510	707570	85
411	613842	106	461	663701	94	511	708421	85
412	614897	105	462	664642	94	512	709270	85
413	615950	105	463	665581	94	513	710117	85
414	617000	105	464	666518	94	514	710963	84
415	618048	105	465	667453	93	515	711807	84
416	619093	104	466	668386	93	516	712650	84
417	620136	104	467	669317	93	517	713491	84
418	621176	104	468	670246	93	518	714330	84
419	622214	104	469	671173	93	519	715167	84
420	623249	103	470	672098	92	520	716003	83
421	624282	103	471	673021	92	521	716838	83
422	625312	103	472	673942	92	522	717671	83
423	626340	103	473	674861	92	523	718502	83
424	627366	102	474	675778	92	524	719331	83
425	628389	102	475	676694	91	525	720159	83
426	629410	102	476	677607	91	526	720986	82
427	630428	102	477	678518	91	527	721811	82
428	631444	101	478	679428	91	528	722634	82
429	632457	101	479	680336	91	529	723456	82
430	633468	101	480	681241	90	530	724276	82
431	634477	101	481	682145	90	531	725095	82
432	635484	100	482	683047	90	532	725912	82
433	636488	100	483	683947	90	533	726727	81
434	637490	100	484	684845	90	534	727541	81
435	638489	100	485	685742	89	535	728354	81
436	639486	99	486	686636	89	536	729165	81
437	640481	99	487	687529	89	537	729974	81
438	641474	99	488	688420	89	538	730782	81
439	642465	99	489	689309	89	539	731589	81
440	643453	98	490	690196	89	540	732394	80
441	644439	98	491	691081	88	541	733197	80
442	645422	98	492	691965	88	542	733999	80
443	646404	98	493	692847	88	543	734800	80
444	647383	98	494	693727	88	544	735599	80
445	648360	97	495	694605	88	545	736397	80
446	649335	97	496	695482	87	546	737193	79
447	650308	97	497	696356	87	547	737987	79
448	651278	97	498	697229	87	548	738781	79
449	652246	97	499	698101	87	549	739572	79

No. 550, Log. 2.740363 to No. 699, Log. 2.844477

No.	Log.	Diff.	No.	Log.	Diff.	No.	Log.	Diff.
550	740363	79	600	778151	72	650	812913	67
551	741152	79	601	778874	72	651	813581	67
552	741939	79	602	779596	72	652	814248	67
553	742725	78	603	780317	72	653	814913	66
554	743510	78	604	781037	72	654	815578	66
555	744293	78	605	781755	72	655	816241	66
556	745075	78	606	782473	72	656	816904	66
557	745855	78	607	783189	71	657	817565	66
558	746634	78	608	783904	71	658	818226	66
559	747412	78	609	784617	71	659	818885	66
560	748188	77	610	785330	71	660	819544	66
561	748963	77	611	786041	71	661	820201	66
562	749736	77	612	786751	71	662	820858	66
563	750508	77	613	787460	71	663	821514	65
564	751279	77	614	788168	71	664	822168	65
565	752048	77	615	788875	71	665	822822	65
566	752816	77	616	789581	70	666	823474	65
567	753583	77	617	790285	70	667	824126	65
568	754348	76	618	790988	70	668	824776	65
569	755112	76	619	791691	70	669	825426	65
570	755875	76	620	792392	70	670	826075	65
571	756636	76	621	793092	70	671	826723	65
572	757396	76	622	793790	70	672	827369	65
573	758155	76	623	794488	70	673	828015	64
574	758912	76	624	795185	70	674	828660	64
575	759668	75	625	795880	69	675	829304	64
576	760422	75	626	796574	69	676	829947	64
577	761176	75	627	797268	69	677	830589	64
578	761928	75	628	797960	69	678	831230	64
579	762679	75	629	798651	69	679	831870	64
580	763428	75	630	799341	69	680	832509	64
581	764176	75	631	800029	69	681	833147	64
582	764923	75	632	800717	69	682	833784	64
583	765669	74	633	801404	69	683	834421	64
584	766413	74	634	802089	69	684	835056	63
585	767156	74	635	802774	68	685	835691	63
586	767898	74	636	803457	68	686	836324	63
587	768638	74	637	804139	68	687	836957	63
588	769377	74	638	804821	68	688	837588	63
589	770115	74	639	805501	68	689	838219	63
590	770852	74	640	806180	68	690	838849	63
591	771587	73	641	806858	68	691	839478	63
592	772322	73	642	807535	68	692	840106	63
593	773055	73	643	808211	67	693	840733	63
594	773786	73	644	808886	67	694	841359	63
595	774517	73	645	809560	67	695	841985	62
596	775246	73	646	810233	67	696	842609	62
597	775974	73	647	810904	67	697	843233	62
598	776701	73	648	811575	67	698	843855	62
599	777427	72	649	812245	67	699	844477	62

No. 700, Log 2.845098 to No. 849, Log 2.928908

No.	Log.	Diff.	No.	Log.	Diff.	No.	Log.	Diff.
700	845098	62	750	875061	58	800	903090	54
701	845718	62	751	875640	58	801	903633	54
702	846337	62	752	876218	58	802	904174	54
703	846955	62	753	876795	58	803	904716	54
704	847573	62	754	877371	58	804	905256	54
705	848189	62	755	877947	57	805	905796	54
706	848805	61	756	878522	57	806	906335	54
707	849419	61	757	879096	57	807	906874	54
708	850033	61	758	879669	57	808	907411	54
709	850646	61	759	880242	57	809	907949	54
710	851258	61	760	880814	57	810	908485	54
721	851870	61	761	881385	57	811	909021	54
712	852480	61	762	881955	57	812	909556	53
713	853090	61	763	882525	57	813	910091	53
714	853698	61	764	883093	57	814	910624	53
715	853306	61	765	883661	57	815	911158	53
716	854913	61	766	884229	57	816	911690	53
717	855519	61	767	884795	57	817	912222	53
718	856124	60	768	885361	57	818	912753	53
719	856729	60	769	885926	56	819	913284	53
720	857332	60	770	886491	56	820	913814	53
721	857935	60	771	887054	56	821	914343	53
722	858537	60	772	887617	56	822	914872	53
723	859138	60	773	888179	56	823	915400	53
724	859739	60	774	888741	56	824	915927	53
725	860338	60	775	889302	56	825	916454	53
726	860937	60	776	889862	56	826	916980	53
727	861534	60	777	890421	56	827	917506	52
728	862131	60	778	890980	56	828	918030	52
729	862728	60	779	891537	56	829	918555	52
730	863323	59	780	892095	56	830	919078	52
731	863917	59	781	892651	56	831	919601	52
732	864511	59	782	893207	56	832	920123	52
733	865104	59	783	893762	55	833	920645	52
734	865696	59	784	894316	55	834	921166	52
735	866287	59	785	894870	55	835	921686	52
736	866878	59	786	895423	55	836	922206	52
737	867467	59	787	895975	55	837	922725	52
738	868056	59	788	896526	55	838	923244	52
739	868644	59	789	897077	55	839	923762	52
740	869232	59	790	897627	55	840	924279	52
741	869818	59	791	898176	55	841	924796	52
742	870404	58	792	898725	55	842	925312	52
743	870989	58	793	899273	55	843	925828	51
744	871573	58	794	899821	55	844	926342	51
745	872156	58	795	900367	55	845	926857	51
746	872739	58	796	900913	55	846	927370	51
747	873321	58	797	901458	54	847	927883	51
748	873902	58	798	902003	54	848	928396	51
749	874482	58	799	902547	54	849	928908	51

No. 850, Log 2.929419 to No. 999, Log 2.999565

No.	Log.	Diff.	No.	Log.	Diff.	No.	Log.	Diff.
850	929419	51	900	954243	48	950	977724	46
851	929930	51	901	954725	48	951	978181	46
852	930440	51	902	955207	48	952	978637	46
853	930949	51	903	955688	48	953	979093	46
854	931458	51	904	956168	48	954	979548	46
855	931966	51	905	956649	48	955	980003	45
856	932474	51	906	957128	48	956	980458	45
857	932981	51	907	957607	48	957	980912	45
858	933487	51	908	958086	48	958	981366	45
859	933993	51	909	958564	48	959	981819	45
860	934498	50	910	959041	48	960	982271	45
861	935003	50	911	959518	48	961	982723	45
862	935507	50	912	959995	48	962	983175	45
863	936011	50	913	960471	48	963	983626	45
864	936514	50	914	960946	47	964	984077	45
865	937016	50	915	961421	47	965	984527	45
866	937518	50	916	961895	47	966	984977	45
867	938019	50	917	962369	47	967	985426	45
868	938520	50	918	962843	47	968	985875	45
869	939020	50	919	963316	47	969	986324	45
870	939519	50	920	963788	47	970	986772	45
871	940018	50	921	964260	47	971	987219	45
872	940516	50	922	964731	47	972	987666	45
873	941014	50	923	965202	47	973	988113	45
874	941511	50	924	965672	47	974	988559	45
875	942008	50	925	966142	47	975	989005	45
876	942504	50	926	966611	47	976	989450	44
877	943000	49	927	967080	47	977	989895	44
878	943495	49	928	967548	47	978	990339	44
879	943989	49	929	968016	47	979	990783	44
880	944483	49	930	968483	47	980	991226	44
881	944976	49	931	968950	47	981	991669	44
882	945469	49	932	969416	47	982	992111	44
883	945961	49	933	969882	47	983	992554	44
884	946452	49	934	970347	46	984	992995	44
885	946943	49	935	970812	46	985	993436	44
886	947434	49	936	971276	46	986	993877	44
887	947924	49	937	971740	46	987	994317	44
888	948413	49	938	972203	46	988	994757	44
889	948902	49	939	972666	46	989	995196	44
890	949390	49	940	973128	46	990	995635	44
891	949878	49	941	973590	46	991	996074	44
892	950365	49	942	974051	46	992	996512	44
893	950851	49	943	974512	46	993	996949	44
894	951338	49	944	974972	46	994	997386	44
895	951823	48	945	975432	46	995	997823	44
896	952308	48	946	975891	46	996	998259	44
897	952792	48	947	976350	46	997	998695	44
898	953276	48	948	976808	46	998	999131	44
899	953760	48	949	977266	46	999	999565	43

SINES 0° to 45° 50′, for each 10 minutes.

Degs.	0′	10′	20′	30′	40′	50′	Degs.
0		7.463726	7.764754	7.940842	8.065776	8.162681	89
1	8.241855	8.308794	8.366777	8.417919	.463665	.505045	88
2	.542819	.577566	.609734	.639680	.667689	.693998	87
3	.718800	.742259	.764511	.785675	.805852	.825130	86
4	.843585	.861283	.878285	.894643	.910404	.925609	85
5	.940296	.954499	.968249	981573	.994497	9.007044	84
6	9.019235	9.031089	9.042625	9.053859	9.064806	.075480	83
7	.085894	.096062	.105992	.115698	.125187	134470	82
8	.143555	.152451	.161164	.169702	.178072	.186280	81
9	.194332	.202234	.209992	.217609	.225092	.232444	80
10	.239670	.246775	.253761	.260633	.267395	.274049	79
11	.280599	.287048	.293399	.299655	.305819	.311893	78
12	.317879	.323780	.329599	.335337	.340996	.346579	77
13	.352088	.357524	.362889	.368185	.373414	.378577	76
14	.383675	.388711	.393685	.398600	.403455	.408254	75
15	.412996	.417684	.422318	.426899	.431429	.435908	74
16	.440338	.444720	.449054	.453342	.457584	.461782	73
17	.465935	.470046	.474115	.478142	.482128	.486075	72
18	.489982	.493851	.497682	.501476	.505234	.508956	71
19	.512642	.516294	.519911	.523495	.527046	.530565	70
20	.534052	.537507	.540931	.544325	.547689	.551024	69
21	.554329	.557606	.560855	·564075	.567269	.570435	68
22	.573575	.576689	.579777	·582840	.585877	.588890	67
23	.591878	.594842	.597783	·600700	.603594	.606465	66
24	.609313	.612140	.614944	·617727	.620488	.623229	65
25	.625948	.628647	.631326	.633984	.636623	·639242	64
26	.641842	.644423	.646984	.649527	.652052	.654558	63
27	.657047	.659517	.661970	.664406	.666824	.669225	62
28	.671609	.673977	.676328	.678663	.680982	.683284	61
29	685571	.687843	.690098	.692339	.694564	.696775	60
30	.698970	.701151	.703317	.705469	.707606	.709730	59
31	.711839	713935	.716017	·718085	.720140	.722181	58
32	.724210	.726225	.728227	·730217	.732193	.734157	57
33	.736109	.738048	.739975	·741889	.743792	.745683	56
34	.747562	.749429	.751284	.753128	.754960	.756782	55
35	.758591	.760390	.762177	.763954	.765720	.767475	54
36	.769219	.770952	.772675	.774388	.776090	.777781	53
37	.779463	.781134	.782796	.784447	.786089	.787720	52
38	.789342	.790954	.792557	.794150	.795733	.797307	51
39	.798872	.800427	.801973	.803511	.805039	.806557	50
40	.808067	.809569	.811061	.812544	.814019	.815485	49
41	.816943	.818392	.819832	.821265	.822688	.824104	48
42	.825511	.826910	.828301	.829683	.831058	.832425	47
43	.833783	.835134	.836477	.837812	.839140	.840459	46
44	.841771	.843076	844372	.845662	.846944	.848218	45
45	.849485	.850745	.851997	.853242	.854480	.855711	44
Degs.	60′	50′	40′	30′	20′	10′	Degs.

COSINES 44° 10′ to 90°, for each 10 minutes.

SINES 46° to 90°, for each 10 minutes.

Degs.	0′	10′	20′	30′	40′	50′	Degs.
46	9.856934	9.858151	9.859360	9.860562	9.861758	9.862946	43
47	.864127	.865302	.866470	.867631	.868785	.869933	42
48	.871073	.872208	.873335	.874456	.875571	.876678	41
49	.877780	.878875	.979963	.881046	·882121	.883191	40
50	.884254	.885311	.886362	.887406	.888444	.889477	39
51	.890503	.891523	.892536	.893544	.894546	.895542	38
52	.896532	.897516	.898494	.899467	.900433	.901394	37
53	.902349	.903298	.904241	.905179	.906111	·907037	36
54	.907958	.908873	.909782	.910686	.911584	.912477	35
55	.913365	.914246	.915123	.915994	.916859	.917719	34
56	.918574	.919424	.920268	.921107	.921940	.922768	33
57	.923591	.924409	.925222	.926029	926831	.927629	32
58	.928420	.929207	.929989	.930766	.931537	.932304	31
59	.933066	.933822	.934574	.935320	.936062	.936799	30
60	.937531	.938258	.938980	.939697	.940409	.941117	29
61	.941819	.942517	.943210	.943899	.944582	.945261	28
62	.945935	.946604	.947269	.947929	.948584	.949235	27
63	.949881	.950522	.951159	.951791	.952419	.953042	26
64	.953660	.954274	.954883	.955488	.956089	.956684	25
65	.957276	.957863	.958445	.959023	.959596	.960165	24
66	.960730	.961290	.961846	.962398	.962945	.963488	23
67	.964026	.964560	.965090	.965615	.966136	.966653	22
68	.967166	.967674	.968178	.968678	.969173	.969665	21
69	.970152	.970635	.971113	.971588	.972058	.972524	20
70	.972986	.973444	.973897	.974347	.974792	.975233	19
71	.975670	.976103	.976532	.976957	.977377	.977794	18
72	.978206	.978615	.979019	.979420	.979816	.980208	17
73	.980596	.980981	.981361	.981737	.982109	.982477	16
74	.982842	.983202	.983558	.983911	.984259	.984603	15
75	.984944	.985280	.985613	.985942	.986266	.986587	14
76	.986904	.987217	.987526	.987832	.988133	.988430	13
77	.988724	.989014	.989300	.989582	.989860	.990134	12
78	.990404	.990671	.990934	.991193	.991448	.991699	11
79	.991947	.992190	.992430	.992666	.992898	.993127	10
80	.993351	.993572	.993789	.994003	.994212	.994418	9
81	.994620	.994818	.995013	.995203	.995390	.995573	8
82	.995753	.995928	.996100	.996269	.996433	.996594	7
83	.996751	.996904	.997053	.997199	.997341	.997480	6
84	.997614	.997745	.997872	.997996	.998116	.998232	5
85	.998344	.998453	.998558	.998659	.998757	.998851	4
86	.998941	.999027	.999110	.999189	.999265	.999336	3
87	.999404	.999469	.999529	.999586	.999640	.999689	2
88	.999735	.999778	.999816	.999851	.999882	.999910	1
89	.999934	.999954	.999971	.999983	.999993	.999998	0
90	10.000000	.....	.....	.....	.....	.....	...
Degs.	60′	50′	40′	30′	20′	10′	Degs.

COSINES 0° to 44°, for each 10 minutes.

NATURAL SINES, TANGENTS, AND SECANTS,

WITH THEIR COSINES, COTANGENTS, AND COSECANTS,

To every degree of the Quadrant, radius being 1.000000.

Note.—From 0 to 45 degrees the name of the column is at the head of the page; from 45 to 90 degrees the name of the column is at the foot of the page.

Arc.	Sine.	Cosine.	Tangent.	Cotan.	Secant.	Cosec.	Arc.
0°	.000000	1.000000	.000000	Infinite.	1.000000	Infinite.	90°
1	.017452	.999848	.017455	57.28996	1.000152	57.29869	89
2	.034899	.999391	.034921	28.63625	1.000609	28.65371	88
3	.052336	.998630	.052408	19.08114	1.001372	19.10732	87
4	.069756	.997564	.069927	14.30066	1.002442	14.33559	86
5	.087156	.996195	.087489	11.43005	1.003820	11.47371	**85**
6	.104528	.994522	.105104	9.514365	1.005508	9.566772	84
7	.121869	.992546	.122784	8.144346	1.007510	8.205509	83
8	.139173	.990278	.140541	7.115370	1.009828	7.185297	82
9	.156434	.987688	.158384	6.313752	1.012465	6.392453	81
10	.173648	.984808	.176327	5.671282	1.015427	5.758771	**80**
11	.190809	.981627	.194380	5.144554	1.018717	5.240843	79
12	.207912	.978148	.212557	4.704630	1.022341	4.809734	78
13	.224951	.974370	.230868	4.331476	1.026304	4.445411	77
14	.241922	.970296	.249328	4.010781	1.030614	4.133566	76
15	.258819	.965926	.267949	3.732051	1 035276	3.863703	**75**
16	.275637	.961262	.286745	3.487414	1.040299	3.627955	74
17	.292372	.956305	.305731	3.270853	1.045692	3.420304	73
18	.309017	.951056	.324920	3.077684	1.051462	3.236068	72
19	.325568	.945519	.344328	2.904211	1.057621	3.071554	71
20	.342020	.939693	.363970	2.747477	1.064178	2.923804	**70**
21	.358368	.933580	.383864	2.605089	1.071145	2.790428	69
22	.374607	.927184	.404026	2.475087	1.078535	2.669467	68
23	.390731	.920505	.424475	2.355852	1.086360	2.559305	67
24	.406737	.913546	.445229	2.246037	1.094636	2.458593	66
25	.422618	.906308	.466308	2.144507	1.103378	2.366202	**65**
26	.438371	.898794	.487733	2.050304	1.112602	2 281172	64
27	.453991	.891007	.509525	1.962611	1.122326	2.202689	63
28	.469472	.882948	.531709	1.880727	1.132570	2.130045	62
29	.484810	.874620	.554309	1.804048	1.143354	2.062665	61
30	.500000	.866025	.577350	1.732051	1.154701	2.000000	**60**
31	.515038	.857167	.600861	1.664280	1.166633	1.941604	59
32	.529919	.848048	.624869	1.600335	1.179178	1.887080	58
33	.544639	.838671	.649408	1.539865	1.192363	1.836079	57
34	.559193	.829038	.674509	1.482561	1.206218	1.788292	56
35	.573576	.819152	.700208	1.428148	1.220775	1.743447	**55**
36	.587785	.809017	.726543	1.376382	1.236068	1.701302	54
37	.601815	.798636	.753544	1.327045	1.252136	1.661640	53
38	.615661	.788011	.781286	1.279942	1.269018	1.624269	52
39	.629320	.777146	.809784	1.234897	1.286760	1.589016	51
40	.642788	.766044	.839100	1.191754	1.305407	1.555724	**50**
41	.656059	.754710	.869287	1.150368	1.325013	1.524253	49
42	.669131	.743145	.900404	1.110613	1.345633	1.494477	48
43	.681998	.731354	.932515	1.072369	1.367328	1.466279	47
44	.694658	.719340	.965689	1.035530	1.390164	1.439557	46
45	.707107	.707107	1.000000	1.000000	1.414214	1.414214	**45**
Arc.	Cosine.	Sine.	Cotan.	Tangent.	Cosec.	Secant.	Arc.

CONSTANTS FOR TIDES

OF THE

BRITISH ISLES,

&c., &c., &c.

TABLES 39 to 42c.

TABLE FOR COMPUTING TIME OF HIGH WATER,

FOR TWENTY-FOUR PLACES SPECIFIED,

Shewing the Semi-menstrual Inequality, + a constant; representing the Interval between the Moon's Transit, Two days preceding a London Tide, and the Time of High Water; the Moon's Parallax being 57′, her Declination 15°; the Sun's Parallax 9″.8, and Declination 15°.

NOTE.—*Portland Tides are for a preceding Transit.*

Moon's Transit.	Brest.	Portland. (Note.)	Portsmouth.	Dover.	Sheerness.	London Docks.	Harwich.	Hull.
h. m.	d. h. m.	d. h. m.	d. h. m.	d. h. m.	d. h. m.	d. h. m.	d. h. m	d. h. m.
0 0	1 4 24	0 7 01	1 12 21	1 11 54	2 1 56	2 3 16	2 1 9	1 19 28
1 0	1 4 8	0 6 47	1 12 08	1 11 43	2 1 39	2 2 59	2 0 54	1 19 12
2 0	1 3 52	0 6 31	1 11 53	1 11 32	2 1 22	2 2 43	2 0 40	1 18 57
3 0	1 3 39	0 6 11	1 11 40	1 11 21	2 1 9	2 2 29	2 0 27	1 18 45
4 0	1 3 33	0 5 49	1 11 32	1 11 13	2 1 3	2 2 24	2 0 18	1 18 39
5 0	1 3 35	0 5 27	1 11 32	1 11 12	2 1 10	2 2 29	2 0 21	1 18 54
6 0	1 3 56	0 5 17	1 11 49	1 11 22	2 1 37	2 2 56	2 0 44	1 19 18
7 0	1 4 33	0 5 40	1 12 21	1 11 47	2 2 12	2 3 27	2 1 20	1 19 42
8 0	1 4 56	0 6 18	1 12 47	1 12 12	2 2 32	2 3 50	2 1 39	1 20 1
9 0	1 5 00	0 6 55	1 12 54	1 12 17	2 2 33	2 3 52	2 1 44	1 20 2
10 0	1 4 51	0 7 16	1 12 47	1 12 13	2 2 24	2 3 45	2 1 37	1 19 53
11 0	1 4 38	0 7 12	1 12 34	1 12 04	2 2 11	2 3 31	2 1 24	1 19 42

Moon's Transit.	Sunderland.	North Shields.	Leith.	Thurso.	Greenock.	Liverpool.	Pembroke.	Weston super Mare.
h. m.	d. h. m.	d. h. m.	d. h. m.	d. h. m.	d. h. m.	d. h. m.	d. h. m.	d. h. m.
0 0	1 16 18	1 16 19	1 15 15	1 9 04	1 12 48	1 12 00	1 6 51	1 7 34
1 0	1 16 02	1 16 05	1 15 00	1 8 50	1 12 34	1 11 45	1 6 35	1 7 18
2 0	1 15 48	1 15 52	1 14 47	1 8 37	1 12 18	1 11 29	1 6 20	1 7 00
3 0	1 15 38	1 15 41	1 14 36	1 8 28	1 12 04	1 11 15	1 6 07	1 6 42
4 0	1 15 35	1 15 38	1 14 34	1 8 26	1 11 55	1 11 06	1 5 55	1 6 24
5 0	1 15 42	1 15 50	1 14 45	1 8 35	1 11 56	1 11 10	1 5 50	1 6 17
6 0	1 16 08	1 16 20	1 15 13	1 9 06	1 12 15	1 11 37	1 5 58	1 6 34
7 0	1 16 36	1 16 49	1 15 42	1 9 43	1 12 46	1 12 16	1 6 32	1 7 07
8 0	1 16 51	1 17 03	1 15 58	1 9 59	1 13 09	1 12 35	1 7 03	1 7 37
9 0	1 16 55	1 17 01	1 15 55	1 9 54	1 13 14	1 12 35	1 7 14	1 7 54
10 0	1 16 49	1 16 50	1 15 47	1 9 38	1 13 10	1 12 25	1 7 14	1 7 55
11 0	1 16 34	1 16 34	1 15 33	1 9 21	1 13 01	1 12 13	1 7 05	1 7 47

Moon's Transit.	Holyhead.	Kingstown.	Belfast.	Londonderry.	Sligo.	Galway.	Queenstown.	Waterford.
h. m.	d. h. m.	d. h. m.	d. h. m.	d. h. m.	d. h. m.	d. h. m.	d. h. m.	d. h. m.
0 0	1 10 47	1 11 47	1 11 25	1 8 38	1 5 55	1 5 14	1 5 41	1 6 01
1 0	1 10 30	1 11 34	1 11 09	1 8 19	1 5 39	1 5 00	1 5 26	1 5 47
2 0	1 10 18	1 11 21	1 10 57	1 8 01	1 5 25	1 4 46	1 5 11	1 5 32
3 0	1 10 10	1 11 10	1 10 49	1 7 48	1 5 11	1 4 35	1 4 57	1 5 16
4 0	1 10 07	1 11 06	1 10 49	1 7 54	1 5 09	1 4 31	1 4 45	1 5 02
5 0	1 10 16	1 11 15	1 10 57	1 8 20	1 5 25	1 4 36	1 4 42	1 4 59
6 0	1 10 46	1 11 38	1 11 20	1 8 57	1 5 53	1 5 01	1 5 00	1 5 20
7 0	1 11 16	1 12 03	1 11 48	1 9 19	1 6 21	1 5 33	1 5 32	1 5 44
8 0	1 11 31	1 12 21	1 12 06	1 9 21	1 6 38	1 5 49	1 5 59	1 6 08
9 0	1 11 31	1 12 28	1 12 05	1 9 15	1 6 34	1 5 50	1 6 08	1 6 23
10 0	1 11 20	1 12 19	1 11 56	1 9 08	1 6 22	1 5 42	1 6 04	1 6 24
11 0	1 11 06	1 12 03	1 11 42	1 8 56	1 6 10	1 5 29	1 5 53	1 6 16

TABLE FOR COMPUTING HEIGHTS OF HIGH WATER,

FOR TWENTY-FOUR PLACES SPECIFIED,

Shewing the Semi-menstrual Inequality, + a constant; in the Height of High Water, with reference to the apparent Solar time of the Moon's Transit B, the Moon's Parallax being 57′, and her Declination 15°; the Sun's Parallax 8″.1, and Declination 15°.

NOTE.—*Portland Tides are for a preceding Transit.*

Moon's Transit.	Brest.	Portland. (Note.)	Portsmouth.	Dover.	Sheerness.	London Docks	Harwich.	Hull.
h. m.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.
0 0	19.06	6.60	12.62	18.66	16.10	19.51	11.56	20.87
1 0	18.92	6·75	12.51	18.61	15.96	19.45	11.38	20.75
2 0	18.36	6.56	12.29	18.24	15.59	19.10	11.10	20.17
3 0	17.31	6.24	11.84	17.54	14.98	18.48	10.72	19.18
4 0	15.88	5.75	11.24	16.48	14.17	17.65	10.28	18.05
5 0	14.47	5.10	10.57	15.36	13.46	16.85	9.88	16.96
6 0	13.83	4.54	10.07	14.51	13.10	16.33	9.72	16.34
7 0	14.08	4.17	10.19	14.72	13.48	16.39	9.95	16.78
8 0	15.17	4.42	10.91	15.75	14.21	17.00	10.43	18.06
9 0	16.66	4.90	11.62	16.85	14.96	17.85	10.94	19.22
10 0	18.03	5.50	12.18	17.78	15.61	18.64	11.38	20.09
11 0	18.84	6.11	12.52	18.41	16.03	19.22	11.57	20.63

Moon's Transit.	Sunderland.	North Shields.	Leith.	Thurso.	Greenock.	Liverpool.	Pembroke.	Weston super-Mare.
h. m.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.
0 0	14.43	13.25	16.29	13.25	9.72	25.96	21.00	37.27
1 0	14.26	12.95	16.00	13.00	9.71	25.85	20.82	37.09
2 0	13.71	12.53	15.54	12.46	9.61	25.08	20.24	36.37
3 0	13.01	11.95	14.88	11.67	9.33	23.87	19.25	34.83
4 0	12.22	11.14	13.92	10.76	9.00	22.46	17.96	32.67
5 0	11.46	10.25	13.05	9.98	8.64	20.96	16.58	30.34
6 0	11.02	9.96	12.58	9.52	8.29	20.14	15.63	28.79
7 0	11.25	10.31	12.87	9.61	8.29	20.64	15.77	29.08
8 0	12.09	10.96	13.60	10.30	8.67	22.00	17.00	30.79
9 0	12.95	11.72	14.61	11.45	9.04	23.55	18.54	33.16
10 0	13.64	12.53	15.59	12.52	9.31	24.77	19.81	35.25
11 0	14.14	13.06	16.18	13.18	9.56	25.58	20.62	36.50

Moon's Transit.	Holyhead.	Kingstown.	Belfast.	Londonderry.	Sligo.	Galway.	Queenstown.	Waterford.
h. m.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.
0 0	16.00	10.94	9.43	7.72	11.25	14.83	11.75	12.42
1 0	15.83	10.80	9.37	7.51	11.01	14.68	11.69	12.39
2 0	15.41	10.49	9.24	7.18	10.50	14.20	11.37	12.21
3 0	14.68	10.05	9.00	6.75	9.82	13.43	10.84	11.83
4 0	13.84	9.61	8.63	6.16	9.14	12.34	10.19	11.21
5 0	13.03	9.13	8.30	5.70	8.58	11.30	9.55	10.52
6 0	12.63	8.83	8.09	5.68	8.38	10.87	9.14	9.96
7 0	12.97	9.10	8.07	6.14	8.55	11.17	9.26	10.02
8 0	13.66	9.55	8.36	6.55	9.15	12.02	9.78	10.54
9 0	14.55	10.04	8.86	6.96	9.90	12.98	10.47	11.25
10 0	15.30	10.50	9.22	7.33	10.60	13.82	11.12	11.87
11 0	15.80	10.86	9.41	7.60	11.09	14.49	11.57	12.20

TABLE OF CORRECTIONS FOR THE MOON'S DECLINATION AND PARALLAX,

For the Twenty Places specified.

Note.—For the Moon's Declination, no correction from 14° to 16°.
" " Parallax " " for 57'.

Name of Port.	MOON'S DECLINATION.						MOONS' PARALLAX.				
	0° to 6°+	9.°+ and 21.°—	12.°+ and 18.°—	24° —	27° —	30° —	54' —	55'— and 59'+	56'— and 58+	60' +	61' +
	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.
Brest	.46	.42	.19	.72	1.01	1.31	1.02	.72	.35	1.15	1.56
Portsmouth	.23	.21	.10	.36	.50	.65	.51	.36	.18	.58	.78
Dover	.38	.34	.16	.58	.82	1.07	.83	.77	.29	.86	1.26
Sheerness	.26	.23	.11	.40	.56	.73	.58	.40	.19	.64	.87
London	.29	.26	.12	.45	.63	.82	.64	.45	.22	.72	.97
Harwich	.17	.16	.07	.27	.37	.49	.38	.27	.13	.43	.58
Hull	.41	.36	.16	.63	.88	1.15	.90	.63	.31	1.01	1.36
Sunderland	.29	.26	.12	.45	.63	.82	.64	.45	.22	.72	.97
Leith	.32	.29	.13	.49	.69	.90	.70	.49	.24	.79	1.07
Thurso	.32	.29	.13	.49	.69	.90	.70	.49	.24	.79	1.07
Greenock	.14	.13	.06	.22	.31	.41	.32	.22	.11	.36	.48
Liverpool	.46	.42	.19	.72	1.01	1.31	1.02	.72	.35	1.15	1.56
Pembroke	.46	.42	.19	.72	1.01	1.31	1.02	.72	.35	1.15	1.56
Weston-super-Mare	.75	.68	.31	1.17	1.64	2.13	1.66	1.17	.57	1.77	2.53
Holyhead	.32	.29	.13	.49	.69	.90	.70	.49	.24	.79	1.07
Kingstown	.17	.16	.07	.27	.37	.49	.38	.27	.13	.43	.58
Belfast	.12	.10	.05	.18	.25	.33	.26	.18	.09	.30	.39
Sligo	.23	.21	.10	.36	.50	.65	.51	.36	.18	.58	.78
Galway	.37	.31	.14	.54	.75	.98	.77	.54	.26	.86	1.16
Queenstown (Cork)	.23	.21	.10	.36	.50	.65	.51	.36	.18	.58	.78

DEVONPORT TIDES.

TABLE shewing the Semi-menstrual Inequality, or the interval between the apparent Solar time of the Moon's Transit, 1½ day preceding a Devonport Tide, and the time of High Water; also the same inequality in the height of High Water, the Moon's Declination being 16° 30', and Horizontal Parallax 57'.

Moon's Transit.	Interval.	Height.	Moon's Transit.	Interval.	Height	Moon's Transit.	Interval.	Height
H. M.	H. M.	Feet.	H. M.	H. M.	Feet.	H. M.	H. M.	Feet.
0 30	6.20	15.34	4 30	5.35	12.82	8 30	7.07	13.85
1 30	6.11	15.01	5 30	5.45	12.24	9 30	7.07	14.64
2 30	5.55	14.41	6 30	6.19	12.29	10 30	6.59	15.14
3 30	5.40	13.64	7 30	6.52	12.92	11 30	6.46	15.40

TABLE OF CORRECTIONS FOR THE MOON'S DECLINATION AND PARALLAX.

Moon's Transit.	Moon's Declination.						Moon's Parallax.				
	0° to 3°+	6° to 9°+	12°+ and 21°—	15+ and 18—	24°—	27°—	54'—	55'— and 59+	56— and 58+	60' +	61' +
H. M. A.M.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft
0 30 to 6 0	.26	.18	.13	.04	.31	.44	.80	.54	.27	.81	1.00
6 0 to 11 30	.45	.31	.18	.05	.39	.60	.66	.45	.22	.64	.86

TABLE FOR FINDING THE HEIGHT OF THE TIDE

AT ANY INTERMEDIATE HOURS OR HALF-HOURS

BEFORE OR AFTER HIGH WATER.

The first column gives the several Ranges of Tide; the Low Water is supposed to be Zero at six hours after High Water.

Range. H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.
6 0	5 30	5 0	4 30	4 0	3 30	3 0	2 30	2 0	1 30	1 0	0 30			
Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.			
6 0	5 10	5 6	5 1	4 6	3 9	3 0	2 3	1 6	0 11	0 6	0 2			
7 0	6 10	6 5	5 11	5 3	4 4	3 6	2 7	1 9	1 1	0 7	0 2			
8 0	7 10	7 4	6 9	6 0	5 0	4 0	3 0	2 0	1 3	0 8	0 2			
9 0	8 9	8 3	7 7	6 8	5 8	4 6	3 5	2 4	1 5	0 9	0 3			
10 0	9 9	9 2	8 5	7 5	6 3	5 0	3 9	2 7	1 7	0 10	0 3			
11 0	10 9	10 1	9 4	8 2	6 10	5 6	4 2	2 10	1 9	0 11	0 3			
12 0	11 8	11 0	10 2	8 11	7 6	6 0	4 6	3 1	1 10	1 0	0 4			
13 0	12 8	12 0	11 0	9 8	8 2	6 6	4 10	3 4	2 0	1 0	0 4			
14 0	13 8	12 11	11 10	10 5	8 9	7 0	5 3	3 7	2 2	1 1	0 4			
15 0	14 7	13 10	12 8	11 2	9 5	7 6	5 8	3 10	2 4	1 2	0 5			
16 0	15 7	14 9	13 6	11 11	10 0	8 0	6 0	4 1	2 6	1 3	0 5			
17 0	16 7	15 8	14 4	12 8	10 8	8 6	6 4	4 4	2 8	1 4	0 5			
18 0	17 7	16 7	15 3	13 5	11 3	9 0	6 9	4 7	2 9	1 5	0 5			
19 0	18 6	17 6	16 1	14 2	11 10	9 6	7 1	4 10	2 11	1 6	0 6			
20 0	19 6	18 5	16 11	14 11	12 6	10 0	7 6	5 1	3 1	1 7	0 6			
22 0	21 5	20 3	18 7	16 5	13 9	11 0	8 3	5 7	3 5	1 9	0 7			
24 0	23 5	22 1	20 3	17 11	15 0	12 0	9 0	6 1	3 9	1 11	0 7			
26 0	25 4	23 11	22 0	19 4	16 3	13 0	9 10	6 8	4 0	2 1	0 8			
28 0	27 4	25 9	23 8	20 10	17 6	14 0	10 6	7 2	4 4	2 3	0 8			
30 0	29 3	27 7	25 4	22 4	18 9	15 0	11 3	7 8	4 8	2 5	0 9			
32 0	31 2	29 5	27 0	23 10	20 0	16 0	12 0	8 2	5 0	2 7	0 10			
34 0	33 2	31 3	28 9	25 4	21 3	17 0	12 9	8 8	5 3	2 9	0 10			
36 0	35 1	33 1	30 5	26 10	22 6	18 0	13 6	9 2	5 7	2 11	0 11			
38 0	37 1	35 0	32 1	28 4	23 9	19 0	14 3	9 8	5 11	3 0	0 11			
40 0	39 0	36 10	33 10	29 10	25 0	20 0	15 0	10 2	6 2	3 2	1 0			
H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.
0 0	0 30	1 0	1 30	2 0	2 30	3 0	3 30	4 0	4 30	5 0	5 30			

TIDES OF THE BRITISH ISLES.—TABLE 41.

WITH COASTS OF FRANCE, SPAIN, HOLLAND, &c.

TABLE OF CONSTANTS,

To be added to, or deducted from, the Times and Heights of High Water, for places computed by Tables 39 and 39a.

The Ports of Reference and their Tidal Ranges are in Strong Figures.

PORTS.	Mean Sprg. Rnge.	Constants. Time.	Hght.
	ft. in.	h. m.	ft. in.
BREST	19 0		
Gibraltar	...	−1 27	...
Cadiz	...	−2 2	...
Lisbon (Bar)	...	−1 17	...
Oporto	...	−1 17	...
Ferrol	...	−0 47	...
Santander	..	−0 17	...
Bayonne	...	−0 2	...
Arcachon	...	+0 50	...
Tour de Cordouan	...	−0 10	...
Bordeaux	...	+3 3	...
St. Nazaire	...	−0 7	...
Belle Ile	...	−0 29	...
Port Louis	...	−0 30	...
Ile de Sein	17 3	−0 26	−1 9
Ushant	11 11	−0 15	−0 1
Morlaix	...	+1 0	...
Plougrescan	...	+1 30	...
Bréhat	...	+2 4	...
St. Malo	...	+2 18	...
Granville	...	+2 26	...
St. Helier	...	+2 38	...
Guernsey, St. Peter's	...	+3 1	...
Alderney	...	+2 59	...
Cherbourg	...	+4 2	...
Barfleur	23 3	+5 4	+4 3
La Hogue	...	+4 55	...
Honfleur	23 4	+5 42	+4 4
Quillebœuf	9 5	+6 19	−9 7
Havre	23 10	+6 4	−4 10
Fécamp	23 2	+6 57	+4 2
Dieppe	...	+7 19	...
DEVONPORT	15 6		
Lyme Regis	...	+0 38	...
Exmouth	...	+0 38	...
Torbay	...	+0 17	...
Dartmouth	...	+0 33	...
Plymouth Breakwater	...	−0 6	...
East Looe	...	−0 17	...
Fowey	...	−0 29	...
Falmouth	...	−0 46	...
Penzance	...	−1 13	...
Scilly, St. Mary	...	−1 16	...
PORTSMOUTH	12 8		
Littlehampton	...	−0 5	...
Selsea Bill	...	+0 4	...
Bembridge Point	...	−0 41	..
Southampton	...	−1 11	...
West Cowes	...	−0 56	...
Hurst Camber	...	−1 41	...
Needles Point	...	−1 55	...
Christchurch	...	−2 41	...
Poole	...	−2 31	...
DOVER	18 8		
Boulogne	...	+0 13	...
Cape Grisnez	16 4	+0 15	+2 4
Calais	19 6	+0 37	+0 10
Dunkerque	...	+0 56	...
Nieuport	...	+1 6	...
Ostend	...	+1 13	...

PORTS.	Mean Sprg. Rnge.	Constants. Time.	Hght.
	ft. in.	h. m.	ft. in.
DOVER (*continued*)	18 8		
Flushing	...	+2 8	...
Antwerp	...	+5 13	...
Helvetsluis	...	+3 18	...
Rotterdam	...	+4 33	...
Deal	...	+0 3	...
Folkstone	...	−0 5	...
Dungeness	...	−0 27	...
Rye Bay	...	+0 8	...
Hastings	...	−0 19	...
Beachy Head	...	+0 8	...
Newhaven	...	+0 39	...
Shoreham	17 6	+0 22	−1 2
SHEERNESS	16 0		
Nore	...	−0 7	...
Chatham	...	+0 25	...
LONDON (Bridge)	19 6		
Gravesend	...	−0 57	...
Woolwich	...	−0 30	...
Greenwich	...	−0 24	...
London Docks	19 10	−0 10	+0 4
Margate	...	−2 27	...
Ramsgate	15 5	−2 23	−4 1
HARWICH	11 6		
Yarmouth Roads	5 9	−2 51	−5 8
Lowestoft	7 0	−2 9	−4 6
Orfordness	...	−0 51	...
HULL	20 10		
Flamborough Head	...	−1 59	...
Bridlington	...	−1 50	...
Spurn Point	...	−1 3	...
Great Grimsby	...	−0 53	−1 8
Lynn Deeps	...	−0 29	...
Wells Bar	...	−0 9	...
Wells Harbour	...	+0 31	...
SUNDERLAND	14 4		
Dundee	...	−0 50	+0 2
Dunbar	...	−1 14	0 0
Berwick	...	−1 4	...
Holy Island	...	−0 52	...
Blyth	...	−0 7	...
Tynemouth Bar	...	−0 2	...
Seaham	...	+0 2	...
Hartlepool	...	+0 6	+0 8
Whitby	...	+0 23	...
Scarborough	15 9	+0 49	+1 5
LEITH	16 4		
Wick	...	−2 55	...
Cromarty	...	−2 21	...
Inverness	...	−1 59	...
Banff	...	−1 49	...
Peterhead	...	−1 43	...
Aberdeen	...	−1 17	...
Stonehaven	...	−1 7	...
Montrose	...	−0 52	...
Arbroath	...	−0 42	...
Tay Bar	...	−0 11	...

TIDES OF THE BRITISH ISLES.—Table 41.

WITH COASTS OF FRANCE, SPAIN, HOLLAND, &c.

TABLE OF CONSTANTS,

To be added to, or deducted from, the Times and Heights of High Water, for places computed by Tables 39 and 39a.

The Ports of Reference and their Tidal Ranges are in Strong Figures.

PORTS.	Mean Sprg. Rnge.	Constants. Time.	Hght	PORTS.	Mean Sprg. Rnge.	Constants. Time.	Hght.
	ft. in.	h. m.	ft. in.		ft. in.	h. m.	ft. in.
THURSO	**13 4**			**KINGSTOWN**	**11 0**		
Tobermory	...	−2 52	...	Donaghadee	11 3	+0 3	+0 3
Portree	...	−1 56	...	Lough Stranford, Bar.	...	−0 40	...
Loch Inver	...	−1 47	...	,, Carlingford, Bar	...	−0 30	...
Kyle Akin	...	−2 12	...	Warren Point	14 1	0 00	+3 1
Tanera Summer Isles.	...	−1 51	...	Howth	...	−0 1	...
Stornoway	...	−1 42	...	Dublin Bar	...	+0 2	...
Cape Wrath	...	−0 58	...	Wicklow	...	−0 41	...
Stromness	...	+0 32	...	Arklow	...	−2 25	...
Lerwick	...	+2 2	...				
				BELFAST	**9 6**		
GREENOCK	**9 8**			Ballycastle Bay	2 5	−4 35	−7 1
Port Patrick	...	−0 58	...	Torr Point (Antrim)	1 8	−1 3	−7 10
Loch Ryan	...	−0 56	...	Lough Larne	8 0	−0 13	−1 6
Crinan	...	+4 41	...				
Lamlash	...	−0 19	...	**LONDONDERRY**	**7 8**		
Campbelton	...	−0 23	...	Coleraine	6 2	−1 37	−1 6
Ayr	8 8	−0 18	−1 0	Portrush	5 2	−1 53	−2 6
Ardrossan	...	−0 23	...				
Largs	...	−0 18	...	**SLIGO BAY**	**11 4**		
Inverary	...	−0 2	...	Roundstone	13 1	−0 50	+1 9
Port Glasgow	9 6	+0 10	...	Westport	12 5	−0 21	+1 1
Glasgow	7 9	+1 17	...	Achillbeg	10 10	−0 4	−0 6
				Broadhaven Harbour	10 7	−0 18	−0 9
LIVERPOOL	**26 0**			Ballyweel, Donegal	...	+0 5	...
Beaumaris	21 5	−0 51	−4 7	Killibegs	...	+0 13	...
Fleetwood, Wyre Lght	...	−0 12	...	Lough Rossmore	...	+0 19	...
Boulton-le-Sands	27 3	+0 3	+1 3	Gweedore Bay	10 10	+0 14	−0 6
Whitehaven	23 3	−0 9	−2 9	Sheep Haven	11 11	+0 7	+0 7
St. Bees Head	...	−0 18	...				
Workington	...	−0 19	...	**GALWAY**	**14 10**		
Maryport	...	−0 20	...	Limerick	16 7	+1 45	+1 9
Abbey Head	...	−0 13	...	Mellon	...	+1 26	...
Annan Foot	..	+0 33	...	Foynes Island	15 5	+1 0	+0 7
Port Carlisle	...	+0 47	...	Tarbert	14 3	+0 22	−0 7
				Kilrush	...	+0 7	...
PEMBROKE	**21 0**			Carrigaholt	...	+0 9	...
Swansea (Mumbles)	...	−0 11	...	Kilbaha	13 1	−0 19	−1 9
Llanelly	...	+0 4	...				
Tenby	...	−0 12	...	**QUEENSTOWN**	**11 8**		
Milford, Entrance	...	−0 20	...	Kinsale	11 4	−0 18	−0 4
				Courtmacsherry	10 7	−0 25	−1 1
Weston-super-Mare	**37 3**			Castletownsend	10 8	−0 40	−1 0
St. Ives	...	−2 10	...	Baltimore	...	−0 38	...
Padstow	...	−1 41	...	Skull	9 7	−0 59	2 1
Lundy Island	...	−1 39	...	Crookhaven	...	−0 52	...
Barnstaple Bar	...	−1 24	...	Dunmanus Harbour	9 4	−1 4	−2 4
Ilfracombe	...	−1 12	...	Dnbeacn., Dunm. Bay	10 1	−1 10	−1 7
Bridgewater Bar	35 0	−0 4	−2 3	Black Ball Harbour	9 5	−1 21	−2 3
Portishead	35 9	+0 22	−1 6	Castletown, Bearhaven	9 8	−0 47	−2 0
Kingroad (Bristol)	...	+0 2	...	Bantry Harbour	10 1	−1 14	−1 7
Cardiff	...	+0 5	...	West Cove, Knmre. R.	9 11	−1 9	−1 9
				Valentia Harbour	11 0	−1 19	−0 8
HOLYHEAD	**16 1**						
Fishguard Pier	11 8	−3 15	−4 5	**WATERFORD**	**12 4**		
Cardigan	...	−3 10	...	Wexford	5 0	+2 1	−7 4
Aberystwith	13 1	−2 40	−3 0	New Ross	12 5	+0 44	+0 1
Aberdovey	...	−2 11	...	Waterford Bridge	13 4	+0 40	+1 0
Barmouth	...	−2 31	...	Dunmore	12 2	+0 7	−0 2
Bardsea Island	...	−2 31	...	Ballinacrty., Dngarvn.	12 4	−0 8	0 0
Porth Dynlaen	...	−1 41	...	Youghal	12 7	−0 6	+0 3
Carnarvon	13 10	−0 38	−2 3	Ballycotton	11 11	−0 26	−0 5

TABLE FOR FINDING VALUE

OF

ANNUITIES AND LEASES, HELD FOR A CERTAIN TERM.

Rule.—The tabular number in the column of the estimated rate of interest, opposite the number of years the lease is to continue, multiplied by the annual rental, will give the value.

For Freeholds, take the number in the line marked "Perp," from the column of the estimated rate of interest.

Years of Lease, Ann., &c.	YEARS' PURCHASE.							
	3 ℔ Cent.	4 ℔ Cent.	5 ℔ Cent.	6 ℔ Cent.	7 ℔ Cent.	8 ℔ Cent.	9 ℔ Cent.	10 ℔ Cent.
5	4.58	4.45	4.33	4.21	4.10	3.99	3.89	3.79
10	8.53	8.11	7.72	7.36	7.02	6.71	6.42	6.14
15	11.94	11.12	10.38	9.71	9.11	8.56	8.06	7.61
20	14.88	13.59	12.46	11.47	10.59	9.82	9.13	8.51
21	15.42	14.03	12.82	11.76	10.84	10.02	9.29	8.65
22	15.94	14.45	13.16	12.04	11.06	10.20	9.44	8.77
23	16.44	14.86	13.49	12.30	11.27	10.37	9.58	8.88
24	16.94	15.25	13.80	12.55	11.47	10.53	9.71	8.99
25	17.41	15.62	14.09	12.78	11.65	10.67	9.82	9.08
26	17.88	15.98	14.38	13.00	11.83	10.81	9.93	9.16
27	18.33	16.33	14.64	13.21	11.99	10.94	10.03	9.24
28	18.76	16.66	14.90	13.41	12.14	11.05	10.12	9.31
29	19.19	16.98	15.14	13.59	12.28	11.16	10.20	9.37
30	19.60	17.29	15.37	13.77	12.41	11.26	10.27	9.43
31	20.00	17.59	15.59	13.93	12.53	11.35	10.34	9.48
32	20.39	17.87	15.80	14.08	12.65	11.43	10.41	9.53
33	20.77	18.15	16.00	14.23	12.75	11.51	10 46	9.57
34	21.13	18.41	16.19	14.37	12.85	11.59	10.52	9.61
35	21.49	18.67	16.37	14.50	12.95	11.65	10.57	9.64
36	21.83	18 91	16.55	14.62	13.04	11.72	10.61	9.68
37	22.17	19.14	16.71	14.74	13.12	11.78	10.65	9.71
38	22.49	19.37	16.87	14.85	13.19	11.83	10.69	9.73
39	22.80	19.58	17.02	14.95	13.26	11.88	10.73	9.76
40	23 12	19.79	17.16	15.05	13.33	11.93	10.76	9.78
45	24.52	20.72	17.77	15.46	13.61	12.11	10.88	9.86
50	25.73	21.48	18.26	15.76	13.80	12.23	10.96	9.92
55	26.77	22.11	18.63	15.99	13.94	12.32	11.01	9.95
60	27.68	22.62	18 93	16.16	14.04	12.38	11.05	9.97
70	29.12	23.40	19.34	16.39	14.16	12.44	11.08	9.99
80	30.20	23.92	19.60	16.51	14.22	12.47	11.10	10.00
90	31.00	24.27	19 75	16.58	14.25	12.49	11.11	10.00
100	31.60	24.51	19.85	16.62	14.27	12.49	11.11	10.00
Perp.	33.33	25.00	20.00	16.67	14.29	12.50	11.11	10.00

TABLE FOR FINDING VALUE

OF

ANNUITIES AND LEASES, HELD FOR A SINGLE LIFE.

Rule.—The tabular number in the column of the estimated rate of interest, opposite the age of the life in the first column, multiplied by the annual rental, will give the value.

Years of Age.	YEARS' PURCHASE.					
	3 ℔ Cent.	4 ℔ Cent.	5 ℔ Cent.	6 ℔ Cent.	7 ℔ Cent.	8 ℔ Cent.
10	20.66	17.52	15.14	13.28	11.81	10.61
15	19.66	16.79	14.59	12.86	11.47	10.34
16	19.44	16.63	14.46	12.76	11.38	10.27
17	19.22	16.46	14.33	12.66	11.30	10.20
18	19.01	16.31	14.22	12.56	11.23	10.14
19	18.82	16.17	14.11	12.48	11.16	10.08
20	18.64	16.03	14.01	12.40	11.09	10.03
21	18.47	15.91	13.92	12.33	11.04	9.99
22	18.31	15.80	13.83	12.27	10.99	9.95
23	18.15	15.68	13.75	12.20	10.94	9.91
24	17.98	15.56	13.66	12 13	10.89	9.87
25	17.81	15.44	13.57	12.06	10.84	9.82
26	17.64	15.31	13.47	11.99	10.78	9.78
27	17.47	15.18	13.38	11.92	10.72	9.73
28	17.29	15.05	13.28	11.84	10.66	9 69
29	17.11	14.92	13.18	11.76	10.60	9.64
30	16.92	14.78	13.07	11.68	10.54	9.58
31	16.73	14.64	12.97	11.60	10.47	9.53
32	16.54	14.50	12.85	11.51	10.40	9.48
33	16.34	14.35	12.74	11.42	10.33	9.42
34	16.14	14.20	12.62	11.33	10.26	9.36
35	15.94	14.04	12.50	11.24	10.18	9.30
36	15.73	13.88	12.38	11.14	10.10	9.23
37	15.52	13.72	12.25	11.04	10.02	9.16
38	15.30	13.55	12.12	10.93	9.94	9.09
39	15.08	13.38	11.98	10.82	9.85	9.02
40	14.85	13.20	11.84	10.71	9.75	8.94
45	13·69	12.28	11.11	10.11	9.26	8.53
50	12.44	11.26	10.27	9.42	8.68	8.04
55	11.15	10.20	9.38	8.67	8.05	7.50
60	9.78	9.04	8.39	7.82	7.31	6.86
70	6.73	6.36	6.02	5.72	5 43	5.18
80	3.78	3.64	3.52	3.39	3.28	3.17
90	1.79	1.76	1.72	1.69	1.66	1.62

TABLE SHEWING PRESENT VALUE OF A REVERSION IN PERPETUITY,

AFTER ANY GIVEN TERM, FROM 10 TO 60 YEARS,

At Rates of Interest from 3 *to* 8 *per Cent.*

Rule.—The tabular number in the column of the estimated rate of interest, opposite the number of years to run, multiplied by the rental, will give the value.

Years to Run.	Years' Purchase at 3 ℔ Cent.	Years' Purchase at 4 ℔ Cent.	Years' Purchase at 5 ℔ Cent.	Years' Purchase at 6 ℔ Cent.	Years' Purchase at 7 ℔ Cent.	Years' Purchase at 8 ℔ Cent.	Years' Purchase at 10 ℔ Cent.
10	24.80	16.89	12.28	9.31	7.26	5.79	3.85
12	23.38	15.61	11.14	8.28	6.34	4.96	3.17
14	22.04	14.44	10.10	7.37	5.54	4.26	2.63
16	20.77	13.35	9.16	6.56	4.84	3.65	2.18
18	19.58	12.34	8.31	5.84	4.23	3.13	1.80
20	18.46	11.41	7.54	5.20	3.69	2.68	1.48
22	17.40	10.55	6.84	4.62	3.22	2.30	1.23
24	16.40	9.75	6.20	4.12	2.82	1.97	1.01
26	15.46	9.02	5.62	3.66	2.46	1.69	.84
28	14.57	8.34	5.10	3.26	2.15	1.45	.69
30	13.73	7.71	4.62	2.90	1.88	1.24	.57
32	12.94	7.13	4.20	2.58	1.64	1.06	.47
34	12.20	6.59	3.81	2.30	1.43	.91	.39
36	11.50	6.09	3.45	2.05	1.25	.78	.32
38	10.84	5.63	3.13	1.82	1.09	.67	.27
40	10.22	5.21	2.84	1.62	.95	.57	.22
42	9.63	4.81	2.58	1.44	.83	.49	.18
44	9.08	4.45	2.34	1.28	.73	.42	.15
46	8.55	4.11	2.12	1.14	.63	.36	.12
48	8.07	3.80	1.92	1.02	.55	.31	.10
50	7.60	3.52	1.74	.90	.48	.27	.08
52	7.17	3.25	1.58	.81	.42	.23	.07
54	6.76	3.01	1.43	.72	.37	.20	.06
56	6.37	2.78	1.30	.64	.32	.17	.05
58	6.00	2.57	1.18	.57	.28	.14	.04
60	5.66	2.38	1.07	.51	.25	.12	.03

Table 42c.

SHEWING THE VALUE OF AN ANNUITY OF £100,

ON A SINGLE LIFE FROM 10 TO 90 YEARS OF AGE.

As Fixed by the Legacy Act.

Age.	Value.	Age.	Value.	Age.	Value.	Age.	Value.
	£ s.		£ s.		£ s.		£ s.
10	1,752 6	30	1,478 2	50	1,126 8	70	636 2
15	1,679 2	35	1,403 18	55	1,020 2	75	496 4
20	1,603 6	40	1,319 14	60	903 18	80	364 6
25	1,543 16	45	1,228 6	65	776 2	90	175 16

MANUAL OF HYDROLOGY.

DIVISION II.

ON RIVERS AND FLOW FROM LARGE DISTRICTS,

WITH PRELIMINARY REMARKS ON

SPRINGS, PERCOLATION, AND WELLS;

ALSO WITH THE

DISCHARGE OF SEWERS AND MATTERS INCIDENTAL THERETO;

AND CHARACTERISTICS OF SOME OF

THE RIVERS OF EUROPE,

&c., &c.

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DIVISION II.

ON

RIVERS & FLOW FROM LARGE DISTRICTS,

WITH PRELIMINARY REMARKS ON

SPRINGS, PERCOLATION, AND WELLS.

SPRINGS AND PERCOLATION.

THERE is perhaps no branch of water-science more vague and capricious than that of the discharge of springs. We have generally very little knowledge, except from the thermometer, of the depth from which the water flows, and the nature of the strata is generally little more than matter of hypothesis. The most certain fact is, that a maximum is rarely exceeded in any spring beyond two to three millions of gallons per diem, and that these are rare cases; the more ordinary flow of large springs being from 100,000 to 500,000 gallons per diem, with a fluctuation between the maximum and minimum period of from 1.0 to .4; but where springs are placed at high elevations with regard to surrounding hills, and there is a small rainfall, they have much greater fluctuations. In this country it is common to experience a total cessation of flow after June or July until October, or later according to the fall of rain in the season.

These remarks are still more applicable to continental and hot countries than to the British Islands, and are only modified in those places where either mountainous elevations or hot climates induce constant recurrence of rain supply.

Probably the more accurate test of the supply due to springs over large areas may be derived from the discharge of rivers either after reasonably dry summers, but when excessive heat has passed away, and, if high mountains exist, when snows have ceased to melt; or in mid-winter when continuous frost has arrested all the surface feeders, and left those only which afford positive spring water. Some of these cases may be traced in examining the Tables of Discharge of Rivers and Details of Flow from Large Districts; but they should be carefully examined with the rainfall for parallel periods, because summer and autumn have not in all years by any means the least rainfall or effective flows therefrom.

The law of distribution of running waters, like that of rain, is decidedly greater and of much larger volume in the higher levels of the country, in proportion to the area drained: such is also the distribution of floods. The friction of channel bed, and time involved in the law of gravitation, afford elements of retardation. From these causes that which is an excessive and damaging flood on a streamlet frequently becomes innocuous on the river into which it flows. This tendency is also increased by the greater power of discharge afforded by larger sectional area—a ratio which would vary in the proportion of the square root of the fifth power of the width of the stream if the depth were half the width; or in other words, if the wetted perimeter be a semicircle. (See Table 6, Division I., for these ratios.)

The general fact also obtains that wide, flat river-valleys store much water when floods are induced; small tributaries, on the other hand, are narrow and steep, having therefore no storing power, and their slope being generally such as to precipitate the flood rapidly upon the lower and flatter districts. We have also the metereological law, that heavy storms of rain have a partiality for hill country, valley heads, and mountain slopes; but if thunderstorms fall on low, flat country, every field and ditch becomes a reservoir (see the Po, and other Rivers, *seq.*) The last-named effect has a marked influence on the general effect of rain in producing either flood, or moderate surface water, or in supplying springs. Autumn rains following a dry summer fall on parched ground, so that the early copious rains are absorbed; in hot countries, where the soil cracks open to a great depth, rains go down direct to the deep sources which supply wells and springs, or lie stored for upward exosmose when vegetation renews its vigour. In a subsequent part of this Division will be found Tables of the Flow of Rivers, and detailed remarks under each case, so far as information is available. It will not be difficult, from the examples given, to ascertain in a rough way the relative proportion of supply which is due to the surface and springs in different climates; but the nature of rocks composing the district in each case form a most important element of the problem.

The first English authority in modern times who has investigated the subject of the relative fall of rain and supply to springs and rivers, was John Dalton: he contrived the percolating gauge, and made extensive experiments on the subject from 1796 to 1798 at Manchester. These will be found in the following page. Associated with them are some experiments by the late Mr. Charnock, of Ferry Bridge, Yorkshire, where there is much less rain than at Manchester. These tables contain the observed evaporation and mean temperature during the period of the observations. In the two successive pages is the well-known series of parallel observations of the ordinary rain gauge kept continuously by the side of a Dalton gauge for twenty-five years at Apsley Mill, on a branch of the Colne, in Hertfordshire. The experiments have been obligingly furnished by Mr. Evans, of King's Langley (Apsley Mill), as kept from 1835 to 1859, by Mr. Dickinson and himself successively. In the Apsley Mill series there appears to be a tendency in the gauge to show less filtration on each average of five years. It is probable that this may partly arise from the general fact of the gradual "puddling" and consolidation of the materials of the gauge in so limited an area; and there is some indication of the materials filling the gauge having possibly been changed after the year 1844. However, be this as it may, there is an important value in experiments of this kind, inasmuch as they afford relative results, and afford strong indications of the periods when the volume of a stream is liable to reduction; as, for instance, the years 1833-4-5 and 1858-9.

The discharge of the River Lee for 1851-2-6, given in a subsequent page, may be referred to as flowing from the same range of hills as the Colne: the mean temperature at Greenwich for each month of these years is given in the same table. Further information on this subject is given in the Hinxworth Experiments; see also, Tables of Rainfall and Evaporation at Oxford, &c., in Division IV. The kind of gauge used in the Manchester and Ferry Bridge cases is described on those tables. The Dalton or percolating gauge at Apsley Mill is registered from two cylindrical vessels, each 18 inches in diameter, one of which is filled for three feet in depth with ordinary soil of the neighbourhood, and the other with chalk of the upper district.

RAINFALL, EVAPORATION, PERCOLATION, AND MEAN TEMPERATURE.

MANCHESTER.

Latitude 53° 27′ N.; Longitude 2° 42′ W.; Height above Sea 200 feet.

Year.	Mean Temp.	Rainfall.				Percolation.				Evapor from Dish.
		1796	1797	1798	Mn.	1796	1797	1798	Mn.	Mn. of 3 years
	Fah	in.	in.	in.	in.	in.	in.	in.	in.	in.
January .	41	3.10	1.58	2.70	2.46	1.90	0.68	1.77	1.45	1.50
February	39	2.29	1.21	1.91	1.80	1.78	0.92	1.12	1.27	2.00
March	41	0.58	0.94	1.18	0.90	0.43	0.07	0.33	0.28	3.50
April	51	1.60	2.18	1.37	1.74	0.22	0.29	0.18	0.23	4.50
May	55	5.09	5.96	1.48	4.18	2.03	2.44	...	1.49	4.96
June	60	2.35	4.26	0.85	2.48	0.17	0.72	...	0.30	6.49
July	60	5.19	2.52	4.75	4.15	0.15	0.03	...	0.06	5.63
August ...	61	1.04	5.49	4.13	3.55	...	...	0.51	0.17	6.05
Sept.	56	2.63	3.80	3.35	3.28	...	0.98	...	0.33	3.89
October ...	48	2.87	2.31	3.51	2.90	...	0.68	...	0.23	2.34
November	41	2.13	2.99	3.68	2.92	...	1.04	1.59	0.88	2.04
December	35	1.76	5.50	2.35	3.20	0.20	3.08	1.88	1.72	1.50
Total	49	30.63	38.80	31.26	33.56	6.88	10.93	7.38	8.41	44.40
WINTER.	39	12.65	6.68	13.10	10.48	7.47	1.80	7.01	5.32	7.03
SPRING.	52	9.62	13.34	4.88	9.28	2.85	3.52	0.51	2.30	19.45
SUMMER.	56	11.73	14.18	15.74	13.88	0.15	1.69	0.51	0.79	17.94

NOTE.—The above Observations were made by Dr. Dalton with a Gauge ten inches diameter and three feet deep, with two pipes, one of which led away any water Percolating, and the other placed near the top; the Gauge was filled for a few inches with gravel and sand, and the remaining portion with good fresh soil. The Percolation measured was that of the water from both pipes; but it is probable that the upper one rarely gave any water. The column of Evaporation is the mean quantity for the three years as observed with an ordinary evaporating dish ten inches diameter. It was from these experiments that Dr. Dalton estimated the mean flow of the River Thames to amount to five inches off the surface.

FERRY BRIDGE, YORKSHIRE.

Latitude 53° 40′ N; Longitude 1° 15′ W.; Height above Sea 30 feet.

Year.	Evaporation From Dish.						Rainfall.						Percolation.					
	1842	1843	1844	1845	1846	Mn. of 5 years	1842	1843	1844	1845	1846	Mn of 5 year	1842	1843	1844	1845	1846	Mn.of 5 yrs.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January .	1.69	2.57	1.61	1.53	2.07	1.89	2.70	1.48	1.31	1.74	2.18	1.88	1.04	0.79	0.46	0.46	0.96	0.74
February	1.23	2.65	1.31	0.71	2.59	1.70	0.76	3.25	2.22	0.73	0.47	1.50	0.08	0.96	0.56	0.30	0.03	0.39
March	1.92	3.05	2.13	2.91	2.56	2.51	3.48	0.95	2.27	1.88	0.93	1.90	1.08	0.23	0.69	0.55	0.07	0.52
April	2.98	3.22	3.83	4.79	1.91	3.35	1.51	2.19	0.27	1.54	5.97	2.30	0.40	0.25	...	0.49	2.99	0.83
May	4.14	2.91	5.77	2.84	4.52	4.04	2.98	2.81	0.42	2.24	0.82	1.85	0.09	0.34	...	0.27	0.09	0.16
June	4.18	5.12	5.31	3.10	4.88	4.52	1.94	2.31	1.24	3.18	1.65	2.06	...	0.21	0.04	0.25	0.07	0.10
July	4.16	3.76	4.17	2.86	4.44	3.88	3.74	2.70	2.76	3.49	2.90	3.12	0.48	0.15	0.33	0.19	0.16	0.26
August ...	3.36	3.71	4.70	2.56	3.08	3.48	1.49	3.99	2.85	4.61	2.65	3.12	0.12	0.22	0.41	0.37	0.19	0.26
Sept.	2.69	2.06	4.91	2.79	2.99	3.09	2.44	1.07	1.92	1.36	1.07	1.57	0.20	0.17	0.30	0.41	0.07	0.23
October ...	2.00	1.80	2.79	2.77	2.23	2.32	1.12	1.10	1.41	3.36	4.09	2.22	0.20	0.28	0.24	0.67	1.69	0.62
November	2.26	1.64	2.84	2.13	1.63	2.10	3.19	2.36	1.98	1.01	1.15	1.94	0.70	0.67	0.51	0.28	0.17	0.47
December	3.00	1.68	0.79	3.57	1.79	2.16	0.76	0.28	0.35	3.04	1.36	1.16	0.16	0.01	0.06	0.68	0.27	0.24
Total	33.61	34.17	40.16	32.56	34.69	35.04	26.11	24.49	19.00	28.18	25.24	24.60	4.55	4.28	3.60	4.92	6.76	4.82
WINTER.	6.34	10.48	6.24	5.87	10.36	7.85	6.56	8.68	6.17	4.80	6.70	6.48	1.84	2.61	1.70	1.33	1.95	1.84
SPRING.	13.22	14.30	17.04	13.64	13.87	14.42	9.91	8.26	4.20	8.84	9.37	8.11	1.57	1.03	0.73	1.56	3.22	1.61
SUMMER.	12.21	11.33	16.57	10.98	12.74	12.77	8.79	8.86	8.94	12.82	10.71	10.03	1.00	0.82	1.28	1.64	2.11	1.37

NOTE.—The above Observations were made by Mr. Charnock; the Evaporation being taken from an ordinary exposed dish as in the previous case; the Percolation was also taken by a Gauge filled with soil in the same manner, the filling being gravel and soil to imitate the Magnesian Limestone formation. The mean temperature of this district would be represented fairly by that of Manchester. Mr. Charnock made continuous experiments on Evaporation from a dish shaded from the Sun, which gave 22.48 inches for 1842; 22.72 inches for 1843; 26.75 inches for 1844; 22.75 inches for 1845; 23.04 inches for 1846. Mean for the five years 23.55 inches. He also made a set of experiments on the Evaporation from soil, from pouring on to the surface of a gauge, filled with soil but without a bottom outlet, as much water as the evaporating dish had shewn in the previous 24 hours; the results gave a mean of 32.70 inches evaporated, during the five years. It was meant to represent the Evaporation from undrained or saturated soil; but it is manifest that such experiments would lead to very wide results.

PERCOLATION AT APSLEY MILL, HERTFORDSHIRE.—25 YEARS' OBSERVATIONS.

Latitude 51° 43′ N.; Longitude 0° 27′ W.; Height above Sea 257 feet.

YEARS.	1835.	1836.	1837.	1838.	1839.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	Mean of 25 years.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in	in.	in.	in.	in.	in.	in.	in.	in.	in.	in	in.
Jan.	...	2.32	2.10	.04	1.04	3.05	...	.60	1.25	.80	2.40	5.05	...	.81	...	...	3.07	2.64	1.27	.95	...	2.28	2.80	1.82	...	1.37
Feb.	...	2.04	2.92	.86	1.51	1.00	...	2.10	1.95	1.50	...	.84	1.76	3.00	.40	.41	.85	1.02	...	.45	1.25	1.30	.32	.59	.05	1.05
March ...	...	2.51	.01	2.73	1.22	...	.53	1.62	...	2.65	...	.02	...	2.75	.05	...	3.18	...	...	...	1.20	.45	...	.80	...	.79
April.....	...	1.74	...	...	.71	...	...	...	...	...	...	.28	...	.70	...	...	.04	...	...	...	.19	.90	1.11	...	...	.23
May	...	.03	...	...	.10	...	...	...	.74	...	...	...	...	...	...	...	...	...	...	...	...	1.70	...	...	...	.10
June.....	.23	.01	...	...	.05	...	...	...	.25	...	...	...	...	...	...	...	...	...	...	...	...	.19	...	...	...	.03
July	.02	.10	...	.09	.15	...	...	...	...	...	...	...	...	...	...	...	...	1.50	...	...	...	...	...	...	...	.07
August...	...	.15	.05	...	.09	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	.01
Sept.....	.21	.07	.05	.03	1.50	...	...	1.30	...	...	...	...	...	...	...	...	...	...	.24	...	...	...	...	...	...	.14
October..	4.75	3.82	.02	.07	.09	...	5.99	.30	.91	1.13	...	3.98	...	2.58	...	...	...	.80	1.65	...	...	...	1.70	...	...	1.07
Nov.	2.17	3.14	.18	2.91	4.70	2.57	4.87	5.00	2.70	3.57	.30	.10	...	.47	...	...	...	6.56	.57	...	1.87	...	1.35	...	1.70	1.79
Dec.	.48	1.82	1.62	1.84	3.75	...	2.80	.84	.30	...	2.80	...	2.38	2.68	1.03	1.39	...	2.11	.60	...	.92	.60	.18	...	2.80	1.27
Total ...	7.86	17.75	6.95	8.57	14.91	6.62	14.19	11.76	8.10	9.65	5.50	10.27	4.14	12.99	1.52	1.80	7.14	14.63	4.33	1.40	5.43	7.42	7.46	3.21	4.55	7.92
Mean of 5 years		11.20				10.6					6.88					5.86					5.62					
WINTER. ...		7.01	9.98	2.70	7.30	12.50	2.57	10.37	9.04	5.30	5.97	8.99	1.86	6.19	3.55	1.44	5.31	3.66	9.94	2.57	1.25	6.37	3.72	3.94	0.05	5.48
Mean of 5 years		6.75				7.95					5.31					4.58					3.07					
SPRING. .23		4.29	.01	2.73	2.08	...	.53	1.62	.99	2.65	...	.30	...	3.45	.05	...	3.22	...	...	...	1.39	3.24	1.11	.80	...	1.15
Mean of 5 years		1.86				1.15					.76					.64					1.31					
SUMMER. 4.98		4.14	.12	.19	1.83	...	5.99	1.60	.91	1.13	...	3.98	...	2.58	...	...	...	2.30	1.89	...	...	...	1.70	...	...	1.29
Mean of 5 years		2.25				1.92					1.31					.84					.34					

RAINFALL AT APSLEY MILL, HERTFORDSHIRE.—25 YEARS' OBSERVATIONS.

Latitude 51° 43′ N.; Longitude 0° 27′ W.; Height above Sea 257 feet.

YEARS.	1835.	1836.	1837.	1838.	1839.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	Mean of 25 Years.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Jan.	1.20	2.40	2.40	.31	1.40	3.95	1.50	1.36	1.46	1.90	3.35	3.97	1.80	1.33	1.80	1.24	3.76	5.15	2.55	2.48	.79	2.97	3.60	.70	1.21	2.18
Feb.	2.62	2.04	2.85	2.65	1.45	1.31	1.02	2.02	2.42	3.62	.70	1.28	1.42	3.25	2.18	1.33	.76	1.15	1.44	.93	1.18	1.46	.21	1.60	1.91	1.71
March ...	3.48	3.65	.75	1.55	1.92	.34	1.65	2.20	.88	2.22	1.30	1.07	.98	3.57	.97	.22	4.30	.34	1.75	.32	2.28	1.07	1.88	1.18	1.77	1.67
April.....	1.67	2.57	1.32	1.35	1.65	.34	1.85	.47	2.10	.33	1.45	2.52	1.68	2.68	2.00	3.00	1.55	1.13	2.60	.86	.40	3.10	2.35	2.46	2.62	1.76
May	2.05	.70	.94	.84	1.22	2.62	1.63	1.85	5.00	.47	2.25	1.59	2.15	.21	2.98	1.67	.75	1.70	1.91	3.48	2.35	3.95	.83	2.33	2.04	1.90
June	3.30	1.80	1.86	2.85	3.31	1.33	3.00	2.00	1.56	1.18	1.60	.51	2.30	3.19	.46	1.20	1.75	4.49	3.70	.97	1.76	1.25	2.20	.65	3.70	2.08
July	.80	2.29	1.30	2.35	4.36	1.18	2.80	1.93	2.09	1.95	2.30	1.90	1.91	2.42	2.79	2.90	2.56	4.70	3.88	1.90	5.00	1.68	1.70	2.63	3.80	2.52
August...	.35	2.24	3.00	.95	3.65	1.90	3.62	1.40	2.66	2.72	1.97	3.28	1.21	2.38	1.88	1.14	2.00	4.08	3.00	1.75	1.43	2.75	3.38	2.40	2.40	2.30
Sept.....	3.82	2.60	1.38	2.47	3.22	2.31	4.00	4.50	.63	1.42	2.00	1.70	2.06	2.12	3.80	1.91	.64	3.87	1.70	.51	1.72	2.13	3.65	1.80	3.75	2.35
October	5.96	4.55	1.55	2.68	1.68	1.50	4.40	1.41	4.82	4.38	1.65	6.36	2.59	4.50	1.82	1.56	2.42	4.80	3.60	2.23	5.47	2.92	5.80	1.94	3.03	3.34
Nov.	2.10	3.95	2.05	3.55	4.40	4.25	4.28	5.77	2.45	3.07	2.94	1.47	1.70	1.12	1.47	2.67	1.03	6.95	1.68	1.31	2.05	1.30	2.06	.78	3.09	2.80
Dec.	.24	2.21	1.70	1.58	3.02	.40	2.30	1.52	.40	.31	3.02	.90	3.40	2.92	2.50	1.66	.66	2.78	.65	1.53	1.46	2.05	.47	2.03	3.30	1.72
Total ...	27.59	31.00	21.10	23.13	31.28	21.44	32.10	26.43	26.47	23.57	24.53	26.55	23.20	29.69	24.65	20.50	22.18	41.14	28.46	18.27	25.89	26.63	28.13	20.50	32.62	26.33
Mean of 5 years.		26.82					26.00					25.72					26.11					26.75				
WINTER.	6.62	6.78	11.41	6.71	7.98	12.69	7.17	9.96	11.17	8.37	7.43	11.21	5.59	9.68	8.02	6.54	8.85	7.99	13.72	5.74	4.81	7.94	7.16	4.83	5.93	8.41
Mean of 5 years.		7.90					9.87					8.38					8.57					6.13				
SPRING.	10.50	8.72	4.87	6.59	8.10	4.63	8.18	6.52	9.54	4.20	6.60	5.69	7.11	9.65	6.41	6.09	8.35	7.66	9.96	5.63	6.79	9.37	7.26	6.62	10.13	7.41
Mean of 5 years.		7.75					6.61					7.09					7.54					8.03				
SUMMER.	10.93	11.68	7.23	8.45	12.91	6.89	14.82	9.24	10.20	10.47	7.92	13.24	7.77	11.42	10.29	7.51	7.62	17.45	12.18	6.39	13.62	9.48	14.53	8.77	12.98	10.51
Mean of 5 years.		10.24					10.32					10.12					10.23					1.88				

SUPPLY OF WELLS.

We are naturally led into this subject when treating of the quantity of water falling over the surface and percolating through the ground, for it is evident that the supply of wells depends upon the freedom with which rocks will permit the passage of water, and on the absence of free discharge at escarpments of lower valleys to which the strata may dip. Faults must of necessity drain away the water due to the strata which they intercept, the extent depending upon the nature of such faults and the free character of the rocks. As faults are generally numerous, it is evident that the supply of wells must vary according to the accident of position and depth; but this rule is not without exception, for there are many districts where, with pervious beds lying in great depth on impervious rocks, water is always to be found at the point where it would naturally be deposited by gravity. The question, is, then, how much water filtrates through and into the lower beds of rocks, or would do so if it were constantly pumped away as it accumulated; or, what is the same thing, how much is relieved by springs having passed through more or less depth of stratification and relieved itself by natural agents into the ordinary channels of discharge.

In Mr. Josiah Parkes' Essays is found the following analysis of the Apsley Mill experiments between 1836 and 1843:—

Year	October to March.			April to September.			Total of each Year.		
	Rain.	Filtratn.	℘ Cent. filtered	Rain.	Filtratn.	℘ Cent filtered	Rain.	Filtratn	℘ Cent. filtered
A.D.	Inches.	Inches.		Inches.	Inches.		Inches.	Inches.	
1836	18.80	15.53	82.7	12.20	2.10	17.3	31.0	17.65	56.9
1837	11.30	6.85	60.6	9.80	.10	1.0	21.10	6.95	32.9
1838	12.32	8.45	68.8	10.81	.12	1.2	23.13	8.57	37.0
1839	13.87	12.31	88.2	17.41	1.60	15.0	31.28	14.91	47.6
1840	11.76	8.19	69.6	9.68	0.00	0.0	21.44	8.19	38.2
1841	16.84	14.19	84.2	15.26	0.00	0.0	32.10	14.19	44.2
1842	14.28	10.46	73.2	12.15	1.30	10.7	26.43	11.76	44.4
1843	12.43	7.11	57.2	14.04	.99	7.1	26.47	8.10	36.0
Mean	13.95	10.39	74.5	12.67	0.90	7.1	26.61	11.29	42.4

The mean of each month for the above eight years, is:—

	Rain, Inches.	Filtration, Inches.	Per cent. Filtered.
January	1.84	1.30	70.7
February	1.97	1.54	78.4
March	1.61	1.08	66.6
April	1.45	.30	21.0
May	1.85	.11	5.8
June	2.21	.04	1.7
July	2.28	.04	1.8
August	2.42	.03	1.4
September	2.64	.37	13.9
October	2.82	1.40	49.5
November	3.83	3.26	84.9*
December	1.64	1.80	100.0

* As to percolation through recent tile-drained ground, Mr. Parkes says that, on a 7th and 8th November, '48 inch rain fell, and on the 9th, '46 passed through to the filter gauge; by an experiment made during the same period on ground drained by one-inch tiles, 24 feet asunder and three deep, which appear to have carried off all in 12 hours, he concludes that they were equal to such a discharge, viz., half an inch in 12 hours.

Referring to the various estimates of the ordinary summer run of streams, and to the amount of rainfall per annum which such run will require, we may safely assume that the mean in a dry summer is not more than ten cubic feet per minute per square mile, which represents a flow from the ground of somewhat more than two inches per annum. If we double this quantity for the average of the whole year, due to springs and ordinary rain, or say four inches, we shall be probably tolerably near the ordinary run of a river, taking summer and winter, *exclusive of floods, and assuming no very wet or high mountain districts.*

Now the average filtration, from April to September, of the above eight years, may be taken as nothing for all practical purposes; while, from October to March, we have an average of 10.39 inches filtered through, out of 13.95 inches total fall. Of this winter portion of 10.39, we must allow at least six inches for floods running away at the time of rain, and then we have only 4.39 inches left from supply of rivers and wells, which, assuming our estimate of four inches for that due to rivers, leaves only .39 of an inch for wells alone. It is certain that this small quantity would give all that we have as yet known of the draft of wells in all ordinary cases; for how notorious is it, that ordinary wells fail in summer time, and how few wells there are of a never-failing character, unless they have some substantial reason for that quality.

It remains to be discussed in what consists the condition of so-called never-failing supply to wells. They are of three classes:—First, when the depth is small so as to catch only the adjacent percolating water which may be expected to travel from the surface within a short period of time: in this class may be placed ordinary domestic wells.

Second—When the depth is great through or into pervious strata, which have a more remote derivation of water, and whose power of drawing such water towards them is created by the depth given to the well, and limited only by the friction of water through the strata: it is the element of friction, even in the most permeable strata, which gives a practical limitation to the supply of water to these wells.

Third—In the third class of wells may be taken those which are sunk into strata which form the *water bed* or absolute reservoir of water flowing from adjacent hills, and having impervious beds below, which uphold such subterranean streams.

It is in the last class that the most prolific wells are always to be found, and obviously when they are at the foot, or within reasonable distance, of adjacent hills. This class includes the successful bores in the beds of green-sand in France, and also most of those in the cretaceous beds of this country. But wells in this formation, as in the red sand-stone, frequently partake of both the second and third classes, owing to upper beds of water which are intercepted and assist in feeding the lower supply. In valley wells near the Thames, and similar rivers, where the chalk is reached most successfully, there is considerable feed given by the valley drift, which round London is rarely more than 30 feet in depth, and reposes generally on the London clay. It may be, however, assumed that wells after long pumping have a tendency to clear and open themselves so as to draw the water through the strata to the bottom rather than from the sides, where it had originally flowed.

When we consider the enormous tendency to collect given to an area by the preponderating gravitation from the surrounding strata produced by pumping at a depth of 100 to 200 or 300 feet below the surface, the wonder should be, rather the small produce of wells generally, than an argument for the great supply from wells. In the construction of a well, new drainage is afforded for the surrounding strata, and

if the water is kept low by the draft, a new condition of the stratification must arise, which increases the tendency to draw from neighbouring sources. Considering the exertions made to get water at Liverpool by wells, the results are small; and of the larger instances in London, some are influenced by the high tide of the Thames, and are greatly assisted by the flow of water in the valley drift.

The previous suggestions as to rainfall liable to percolate downwards to the internal strata are therefore capable of very wide interpretation, for there are three elements of consideration, viz., amount of rain which can be spared for filtration by the superior resisting power of surface channels of drainage; by gravitating power, or working depth of water below surface of ground; and by the friction or permeability of the subterranean strata.

It is obvious, therefore, that wells, if unduly worked, may be another form of taking water out of the adjacent rivers or the springs which supply them: this is a point which is at all events open to question; and the evidence is certainly rather favourable to such a conclusion in chalk districts, where there are adjacent springs on which an effect (if any) can be immediately discovered; for although this may happen, it is not always readily discoverable. In the case of "Dickinson *v.* The Grand Junction Canal Company," where defendants sank a well near the summit level of the streams flowing out of the chalk towards the Colne, and pumped thence over the watershed line into the canal locking northwards, Lord Langdale referred the matter to the late Sir W. Cubitt, the President of the Institution of Civil Engineers: this gentleman suggested that the Canal Company should divide the water pumped, sending half down towards the Colne, and the other half northwards. This was in fact admitting the doctrine, qualified in some degree by the proximity of the well to the watershed line, where the waters naturally had a tendency to divide themselves. The final result of the litigation was a perpetual injunction against taking the water from the well; but this decision was, we believe, grounded on an existing agreement more than on the common-law view of the question. In the Croydon case the Board of Health distinctly reduced the volume of the Wandle by pumping from a well, but the owners of water-power did not succeed in arresting the pumping or in obtaining damages.

Other cases of this class are still undecided, or have minute shades of difference between them, so as to render it difficult to apply any one case to another apparently similar. There is a growing tendency among the Courts to regard the percolating water as a common bed (like a mineral), from which each owner may supply himself, so as he exercises only his strict rights of ownership. In the case of "Johnson *v.* New River Company," defendants (in 1855-56) made deep sewers in the public streets of Hertford, the strata being large flint drift and gravel: the effect of the work was to drain all the water from numerous adjacent wells, and undoubtedly to damage the plaintiff, who obtained a decision in his favour; but on the case being carried to a superior court, the judgment was unanimously reversed, although the judges admitted that it was a hard case for the claimants.

Wells and Springs are identical in character: their essential feature is that of a moderate, uniform and slow amount of supply: this gives rise to the common mistake of much overrating their power; for the store of years is readily mistaken to be perennial. Wells are among the earliest contrivance of the human race, and of the lowest order in civilization; being provisions for the wants of humanity, ordained by Providence, so that man shall have water in detail wherever he may require it, for his daily use; and in order that the supply may be pure, the

chemist informs us that the carbonic acid and other materials in the natural soil constantly purify the percolating water in the slow passage (filtration) downwards; thus returning the liquid pure from the manure and other impurities of the upper soil—from the animal and vegetable wonders of the microscope, children of light and air, that cannot exist below; so that the earth, synonymous with corruption, is also all-powerful in production and support of new life, as described by a great apostle before chemistry was known. Wherever immense populations are gathered together, these conditions are interfered with so as to upset the ordinary economy of nature, and give rise to the complications which the engineer is called upon to adjust.

WELLS PASSING THROUGH TERTIARIES INTO THE UPPER GREENSAND AND CHALK.

The following examples are chiefly taken from papers and discussions in the "Minutes of the Institution of Civil Engineers," and we must leave the reader to draw his own conclusions from the general facts when collated with the foregoing data.

The chief supply to the wells of London is the bed of sand which lies on the chalk under the great bed of London and plastic clays; the nature of this bed renders the communication between different wells frequently very apparent, and it is equally certain that all the large wells have constantly to be deepened, to enable them to keep up their supply.

Mr. Clutterbuck (Mins. Inst. Civ. Engrs.) says, that the permanent depression between 1841 and 1848 has been 12 feet, or 18 inches per annum, the progress being thus:—

Hendon Union Workhouse	6	feet in	8 years.
Cricklewood	10	,,	,,
Kilburn	20	,,	,,
Zoological Gardens, Regent's Park	19	,,	,,
Hampstead Road	10	,,	,,

Mr. F. Braithwaite, who has devoted much attention to this branch of engineering, gives a table to shew the effect of pumping from the sand springs under the blue clay at Coombe's Brewery, Long Acre. The following is an abstract:—

DEPTH OF WATER BELOW GROUND, IN FEET.

	1838.	1841.	1844.	1847.	1849.
January	113.6	119.0	131.0	133.8	148.6
March.....	116.0	121.6	135.6	133.1	152.6
June	113.0	124.0	137.0	139.1	158.0
September ...	118.0	124.3	134.6	146.0	160.6
December ...	117.0	124.6	135.6	140.0	155.9

At Greenwich the well ebbs and flows during each tide in the ..... } Land springs 2 feet. Sand ,, 3 ,,

At Coombe's Brewery, additional borings in the chalk, 100, 200, and 300 feet deep, gave only 4 cubic feet per minute more water: the water of this well has lowered 60 feet and upwards in 25 years.

At Meux's Brewery, 260 feet boring in chalk only gave 1.6 cubic feet per minute more water.

The following is a general statement relating to wells round London, compiled from the same sources: the quantity supplied must be taken with considerable caution, as it is not always the case that the full-stated draft is perpetually being pumped out.

Locality of Wells.	Depth below ground. feet.	Feet T. H. Water. feet.	Deptl. in Chalk. feet.	Deptl Bored feet.	Amount of supply, c. feet per minute.
Bushey Meadows, Watford (*a*).....	...	...	...	...	200.0
Hanwell	...	...	...	...	20.4
Hampstead Road, (*b*) August, 1838	183	105	37	...	10.3
,, March, 1839	...	...	...	...	21.1
Trafalgar Square	400	375	100	...	65.0
Read's – chalk exposed 1,600 sq. ft.	...	...	...	...	32.0
Greenwich Hospital	253	240	130	100	—
Woolwich (*c*)	600	590	580	...	160.0
Booth's at Brentford (*d*)	415	...	...	100	13.0
Well at Gravesend, 1837	...	...	...	...	13.0
Brompton, 1860	170	30	160	120	33.0

(*a*) This well was made through valley drift into chalk close to the Colne, with porous chalk hills all round; the experiment was only made for a short period.

(*b*) Well finished in February, 1838. Depth 183 feet; worked by a 20-horse engine, at a cost of £2. 17s. for each 24 hours. Gross cost of well, engine and pumps, £12,422. See Mr. R. W. Mylne's elaborate papers on wells, and his geological survey of the metropolitan districts.

(*c*) Through valley drift into chalk; steep hill close behind.

(*d*) Supply chiefly from sand springs.

Among successful wells through the tertiary drift into the cretaceous series, may be quoted those at Brighton, where one of the borings is said to afford one million of gallons per diem; at Worthing, the surface of the well being 30 feet above the sea, and 360 feet deep in chalk, gives a most plentiful supply; at Portsmouth and Gosport there are successful wells, giving from 200,000 to 500,000 gallons per diem. So also is the new well of the Brompton Water Company, in a narrow chalk valley about two miles from the Medway at Chatham; and a somewhat parallel case in the Ravenburn Valley, above Lewisham, where the result has been most successful. All these cases have a similar character in the greater or less propinquity of porous hills of chalk in elevation considerably superior to the position of the wells; these hills being generally bare, or more or less covered with superficial drift of a highly pervious character. Wells and bores in the valley of the Lee have been generally successful—say up to 100,000 gallons per diem near the surface; but at Tottenham there is an upthrow of London clay, and below this point results are not so successful. It may be doubted whether the presence of a great thickness of London Clay is not predicative of deficiency in copious water bearing properties of the strata beneath.

Among the unsuccessful cases may be quoted,—Southampton, where the original well was made 160 feet to the chalk, thence 402 more in this material, after which, a boring of 7½ inches was made for 755 feet more, making a total depth of 1,317 feet; the last 12 feet was in chalk marl,

when no water having been found, the project was abandoned, after an enormous amount of expense had been incurred. At Harwich a boring was made by Mr. Bruff, the well-known engineer, through an immense thickness of tertiary strata (London clay); on passing through about 100 feet of chalk and gault, the bore suddenly penetrated a very hard black slaty rock at a total depth of 1,025 feet, when the project was abandoned. The rock had every appearance of being one of the palæozoic series, so that, as at Calais, Ostend, and Highgate, the lower green sand appeared to be absent. Hampstead is a very parallel case to this; the depth of similar beds was traversed to 1,113 feet from the surface (about 800 feet below high water) without finding water, and the parties came to red conglomerates and clays; these continued for nearly 200 feet, so that it was deemed prudent to relinquish the attempt to get water at a depth of 1,302 feet. In the well at Calais the results were precisely similar to those at Harwich; the depth of 1,047 feet completed the cretaceous series, and after boring into transition rocks 103 feet more, the search for water was abandoned.

Mr. George R. Burnell, C.E., who is one of our highest authorities, has written some most admirable and lucid papers upon this subject, and draws especial attention to the uncertain character of deep wells and borings. From this author's description of the French borings, we give the following statements. (See his paper read before the Society of Arts, January 29th, 1862.)

ARTESIAN WELLS PASSING THROUGH CHALK INTO LOWER GREENSAND.

THE GRENELLE AND PASSY WELLS.

In 1833, M. Arago induced the Conseil Municipal of Paris to undertake the execution of a deep boring for a supply of water from the lower green-sand formations, which he supposed to form a continuous bed under the chalk basin, and the tertiary strata of the neighbourhood of Paris. This lower green-sand, in fact, outcrops from under the chalk on the whole of an irregular oval, passing from the north-east through the south, nearly to the north-west of Paris, and it approaches that city the most nearly at the point where the Seine forces its way through the overlying recent formations near Troyes, in Champagne. At Lusigny, the precise point of outcrop, the surface of the green-sand is about 300 or 350 feet above the level of the plain of Grenelle: hence it was thought that water from the green-sand would flow over the surface at Grenelle, and MM. Arago and Walferdin were encouraged in that opinion by the existence of numerous artesian wells carried through the chalk into the same stratum at Elbœuf and Rouen.

On the 29th of November, 1833, the works of the Grenelle well were commenced by M. Mulot, and after encountering many serious difficulties from the nature of the ground, and from the fracture of the tools made to work at so great a distance from the surface, a copious jet of water from the lower green-sand was obtained on the 26th February, 1841. The depth then reached was 1,807 feet, of which 1,378 feet were in the chalk: the water rose at first at the rate of 800,000 gallons per day, to the height of about 122 feet, and its temperature was about 82° Fahr. At first it contained sand, clay, and other matters in suspension, and it was nearly twelve months before the water passages of the subterranean strata were sufficiently cleared to allow the water to rise in a state fit for distribution. On several subsequent occasions, also, the

sand has accumulated in such quantities, in the pipes lining the bore, as to render it necessary to draw and clean them. This boring cost a total sum of £14,000, and took about seven years for its completion; the diameter of the bore was 8 inches.

More recently the municipality arranged with Kind, a German engineer, to make an artesian boring of two feet diameter into the same strata at Passy. This work was commenced early in 1855, and by the 31st of May, 1857, the boring had reached the depth of 1,732 feet from the surface, when the upper portion of the tube collapsed, at a distance of about 100 feet from the surface. This accident delayed the completion of the work for three years; but finally a new well was sunk about 175 feet, and the boring was resumed. Much trouble was encountered in traversing the strata below the distance of 1,732 feet above quoted, and at length, at the distance of about 1,894 feet from the surface, the first water-bearing stratum was met with, but it did not rise to the level of the ground. The boring was continued until the 24th September, 1861, when the true artesian spring was tapped at the depth of 1,923 feet. When the water rose to the surface, its discharge was at the rate of 5,582,000 gallons per day. The yield has since then oscillated, but so long as the column had not been raised above the level of the ground, the total quantity does not seem to have fallen short of 4,465,600 gallons. The well of Grenelle (which, by the way, had been falling off in its yield for some time before the completion of the Passy boring, no doubt on account of some obstruction in its ascensional tube, but which for several days before the 24th September discharged regularly 200,000 gallons per day), fell, in about thirty hours after the Passy spring had been tapped, to a yield of about 173,000 gallons, at which rate it remained stationary, until the tube of the Passy boring was raised so as to allow the water to stand at the same height in the two wells, when the original rate of delivery of the Grenelle well was resumed, but the rate of delivery of that at Passy fell to 2,000,000 gallons per day. The horizontal distance of the Passy well from the one at Grenelle is about 3,830 yards; and the water-bearing stratum is about 100 feet nearer the mean level of the sea at Grenelle than it is at Passy, whilst the surface of the ground is about 35 feet higher at the latter locality than it is at the former one.

The water is undoubtedly the same in both these cases; both have a smell of sulphuretted hydrogen, and are of the same temperature, 82° Fah. The cost of the well at Passy has amounted to £40,000, and the time of construction rather more than seven years.

Mr. Burnell says that at Tours, where many artesian wells have been sunk into the subcretaceous beds, the subterranean supply is becoming exhausted, and, as in the case of the wells supplied by the basement beds of the London clay and chalk, the lower green sand wells are gradually losing their artesian character. In two wells also, at Evres and Ferrières, the subcretaceous formations yielded no water; and in the latter the bore was even carried to a depth of 30 feet in the great oolitic, or jura limestone, series, without obtaining a supply.

It would be wrong to leave this subject without mentioning the artesian borings in the Great Desert of Sahara, being made by the French for some years past. Mr. Burnell says that up to the month of June, 1860, no less than fifty of these wells had been sunk in the desert, and that they pour out jointly 7,920,000 gallons of water per day.

WELLS IN THE NEW RED SANDSTONE.

During the contest as to the mode of supplying water to Liverpool, the late Mr. Robert Stephenson was called upon to investigate the power and cost of supplying from wells in this formation. He had the advantage of existing wells on which to experiment on a very large scale, and he came to the following general conclusions:—

That an abundance of water is stored up in the new red sandstone, and may be obtained by sinking shafts and driving tunnels about the level of low water.

That the sandstone is generally very pervious, admitting of deep wells drawing their supply from distances exceeding one mile; but its permeability is occasionally interfered with by faults or fissures filled with argillaceous matter, sometimes rendering them partially or wholly watertight.

That neither by sinking, tunnelling or boring, can the yield of any well be very materially and permanently increased, except so far as the contributing area may be thereby enlarged.

That the contributing area to any given well is limited by the amount of friction experienced by the movement of the water through the fissures and pores of the sandstone.

That there is evidence to shew that the tendency of the river water inland is slightly preponderating over the pressure of the body of water in the sandstone towards the Mersey, the wells being generally sunk about 20 feet below low water mark.

That it might be a fair conclusion, under existing circumstances, that the equilibrium would be very nearly adjusted, because the mass of the wells draw their supply from the sandstone at a level somewhere between high and low water mark, and the column of fresh water from the sandstone exerting its natural pressure, prevents any ingress from the fluctuating column of tidal water; but that the uniform pressure of the column of fresh water is interfered with by the great extent of pumping from the wells; the effect of this, in many cases, being to lower the surface line of water in the sandstone below the river surface, when a reverse action ensues, and the brackish water obtains a slight advantage.

That the various proposals for obtaining water, *by sinking at one point* in the immediate vicinity of Liverpool, will not produce the stipulated quantity. That experience shews the necessity of deepening the wells in Liverpool, from time to time, from the great demand. That there is little or no probability of obtaining permanently more than about 1,000,000 or 1,200,000 gallons per day, from any one well, and this only when not interfered with by other deep wells.

That the most, if not the only feasible plan for making the water contained in the sandstone available for the general supply of Liverpool, is to sink a series of wells scattered over a large area of country lying to the east or north-east of the town.

The report states that the net cost of working the existing deep wells at Liverpool was as follows:—

Name of Station.	Height Water Lifted.	Quantity Raised.	Total Cost per Ann. of Raising Water.	Cost per ann. of Raising 1,000,000 Gallons, or 160,513 c. feet.
	Feet.	Cubic ft. per Min.	£ s. d.	£ s. d.
Bootle	40	100.6	1,445 3 3	4 7 8
Bush	123	29.1	716 3 5	7 10 1
Soho	123	51.7	833 17 1	4 18 9
Hotham Street	110	24.7	603 4 8	7 9 4
Water Street...	156	45.8	874 7 10	5 16 6
Windsor	210	71.1	949 0 3	4 1 6
Green Lane ...	185	112.2	920 2 7	2 10 1

The gross cost of raising 112 cubic feet per minute, or 1,000,000 gallons per diem, at Green Lane and Windsor Wells, is— .

For current expenses, including superintendence ...£1,100
Depreciation upon engines and machinery, engine-houses and cooling-pond, £11,200 at 2 per cent. 224

Total per annum...£1,324

From which the annual cost of each new station, including mains for delivery into the Distributing Reservoir, is estimated thus :—

Current expenses, including superintendence.....£1,100
Depreciation upon engines and machinery, engine houses and cooling-ponds £12,000 at 2 per cent. } 240
Depreciation of mains, £8,000 at ½ per cent. 20
Interest on capital, namely—£30,800 at 4½ per cent. 1,386
Compensation to landowners 250

Total per annum for distributing 112 cubic feet per minute, exclusive of service pipes ..... } £2,996

Mr. Stephenson suggested that if Liverpool were to be supplied from wells, they should be scattered at wide distances over the area to the east of the town; he estimated that each new station and its mains to the Kensington Reservoirs would cost £28,000 and allowing one station for each 1,000,000 gallons supplied, and the same quantity for each of the two present stations (which cost, exclusive of capital, £2,648 per annum) he made the following comparison of the annual cost of supplying Liverpool with water from wells and from Rivington Pike :—

To obtain				Gravitation. Rivington, including interest on capital of £500,000.	Pumping. Wells, including interest on capital.
Gal. per day,		C. ft. per min.		£	£
8,000,000	or	891.4	would cost	28,100	20,624
9,000,000	,,	1,002.8	,,	28,356	23,620
10,000,000	,,	1,114.3	,,	28,612	26,616
11,000,000	,,	1,225.7	,,	28,868	29,612
12,000,000	,,	1,337.1	,,	29,125	32,608
13,000,000	,,	1,448.6	,,	29,381	35,604

It must be observed that the foregoing case is highly favourable to the production of water; the range of sandstone hills face the sea with a moist climate and considerable rainfall, the rocks are highly porous and permeable; and the rear of Liverpool is composed of flat valleys in the table-land, whence the strata dip towards the Mersey.

Mr. Stephenson's remarks were highly cautious, for his office was to decide between their competing schemes for supply of water to Liverpool. The cost of the Rivington Pike supply has very much exceeded the above estimates; but of course the proposal for wells would have been liable to increase over the estimates.

ON THE FLOW OF RIVERS AND STREAMS.

ESTIMATE OF DISCHARGE IN RELATION TO RAINFALL.

The rain gauge is a most useful instrument in the hands of an engineer, if used with due experience of the effects which its records are known to produce in similar districts; although the result may be occasionally not altogether synchronous, yet on examining the broad facts we shall not find anything at variance with the general laws which govern the collection of vapours and their deposit in rain. Districts may greatly vary in their general slope and geological character: graüwacke, granite, and the volcanic districts generally throw water in great rapidity, and are equally liable to great drought in summer time, unless they are capped by moss beds, which act as sponges not always the most pure; some of the newer rocks, on the other hand, such as the old and new red sandstones, have great power of storing water; the latter rocks, from their flatness, generally holding it as indicated by the wells, which are always plentiful in this formation; the former, on the other hand, generally give out the purest spring water when occurring on mountain slopes, rising above the plains occupied by our numerous coal fields.

In the chalk districts this porous material absorbs a great portion of the rain that it receives, collecting it in great underground sheets represented by the numerously-interlaid flint beds, or in vertical vaults and water-worn channels, and pouring out almost rivers at places that have no indication of a feeder; so strongly is this marked, that the chalk districts may be always identified upon the Ordnance maps by the absence of streamlets on its surface, a characteristic likewise of some of of the mountain limestones and oolites.

In this latter formation we have had occasion to examine springs which, although most copious, could be scarcely recognised to have any area of drainage beyond them; rocks with very flat bedding frequently conducting water far away from the visible surface slopes, and pour it out apparently but little below the summit level of the hills on which the rain supply is precipitated.

These instances are familiar to all who have studied the water-bearing properties of the hills of Great Britain. Watching the progress of agriculture and drainage, we find the hill pastures scored in all directions with sheep drains, while in agricultural districts thorough draining steadily advances, and in manufacturing districts and populous towns everything becomes artificial; all these operations are rapidly contributing to affect the levels at the mouth, or on the lower course of our

rivers, and the incontrovertible order of events is to force on new improvements. Frequently in this state of affairs, the march of improvement has commenced in the harbour at the mouth, and tidal volume is sent up higher and sooner than known before; dredging machines are set to work, and bold piers or long river walls are constructed; and although the landowner may find his outfall better, he also discovers that new conditions may arise out of remote causes.

In the estimates of floods, and description of various rivers in this Division and in the Division III. on Tides, we have endeavoured to sketch out a few examples of cases, with which the engineer should expect to deal, in constructing outfalls or in improving lowland rivers. In hydraulic operations, more than with all others within the scope of engineering, it is absolutely necessary to predict and provide for new effects, for we have not only to deal with Statics but with Dynamics, and with a material having the highest facility of motion.

When investigating the various questions raised within the scope of subjects on which we are now treating, and in generalizing on the water-bearing qualities and powers of discharge of districts in ordinary and flood time, the observer will be well aware, that there are seasons of drought when the most certain streams are seriously affected in their water-bearing properties. The tables exhibit the great quantity of water afforded in some cases; yet we have it on record that almost the whole of the sources in the Pentland Hills were dried up in the summer of 1843. There appear to be, indeed, rare occasions when the hill-country suffers more from drought than lower districts: the lake district of Cumberland was similarly affected at about the same time.

In hotter countries these facts are proverbial. In the great tertiary plains of central Spain, which are 1,200 feet and upwards above the sea, large rivers shrink into dry gravel beds, while at the same time the seaward face of the mountains which fringe the Bay of Biscay, are clothed with verdure caused by perpetual rains; this grand escarpment is broken up into the wildest and most precipitous glens, where the vapours rolling from the sea are caught and poured down with astonishing rapidity and volume. The character of this great condensation, as it were, is so marked that severe droughts are experienced on the inland side of the escarpment (5,000 to 7,000 feet above the sea) while within a few miles rains are daily pouring down. These effects occur in a similar manner along the escarpment of the Bombay peninsula, where the rainfall is from 80 to 150 inches in the year, while it gradually recedes to 10 or 15 inches in the Deccan or dry country; the same is to be traced on the coast of Arracan, and in California on the West Coast of America. The rainfall of the Western Highlands is remarkable, likewise that of the Lake district, both have a similar character with those of the more Southern climates. Particulars of the Rainfall of all these cases are given in Division IV. of this Treatise.

In the following table we give a few examples of actual discharge from several hill districts in the Northern part of Great Britain, where the total flow of water has been gauged for the whole year round, and has been absorbed for economic purposes by artificial works. The Bann Reservoirs, and some of those near Manchester, are from Mr. Bateman's papers in the *Manchester Philosophical Memoirs*.

TABLE OF VOLUME GAUGED OR STORED IN SMALL HILL DISTRICTS,

with the amount given per square mile, the amount of water run off in depth over the surface, and the amount intercepted by reservoirs constructed for economic purposes.

LOCALITY.	Height above Sea.	Drainage Area.	Total Discharge for the Year.	Discharge per Square Mile.	Representing Rainfall per Annum.	Registered Rainfall per Annum.	Reservoir Room per Square Mile.
	ft. ft.	sqre. miles.	cube ft. pr. mn.	cube ft. pr. mn.	ins.	ins.	cu. ft. in millns.
Bann Reservoirs, 1837-8	400 to 2,800	5.15	1092.6	210.2	48.0	72.0	56.0
Greenock, 1827-8 flat moor	512 to 1,000	7.88	1416.6	197.7	41.0	60.0	38.0
Bute (*a*), 1826	200 to 350	7.80	819.0	105.0	23.9	45.4	...
Glencorse, Pentland Hills (*b*)	734 to 1,600	6.00	600.0	100.0	22.3	37.0	7.66
Belmont, 1843, moorland	850 to 1,600	2.81	630.4	224.3	50.7	63.4	26.8
,, 1844 ,,	...	...	412.8	146.4	33.3	50.0	...
,, 1845 ,,	...	...	511.2	181.9	41.2	55.0	...
,, 1846 ,,	...	...	411.3	146.3	33.2	49.8	...
Rivington Pike (*c*) 1847	800 to 1,545	16.25	2880.0	176.7	40.0	55.5	29.6
Longendale..... 1847	500 to 1,800	...	...	...	49.5	55.5	...
Swineshaw 1847	500 to 1,800	...	...	...	37.0	49.3	...
Turton and Entwistle, 1836.	500 to 1,300	3.18	576.7	181.3	41.0	46.2	31.43
Turton and Entwistle, 1837.	...	...	548.2	172.3	39.0	48.2	...
Bolton Waterworks ...	800 to 1,600	.80	100.2	125.2	32.7	...	25.6
Ashton 1844	800	.59	40.7	65.5	15.5	40.0	21.0

(*a*) This year's rain was about 12 inches less than an average.

(*b*) Glencorse discharge is only the amount exclusive of floods; the reservoir supply totally failed in the drought of 1826 and 1843; the rainfall is given in Division IV. of this work; the amount of Reservoir has been doubled since this estimate was made, and its power of supply in ordinary years of rain has been thereby much increased. The Glencorse drainage is generally precipitous.

(*c*) Rivington Pike Reservoirs were not made when these gaugings were taken. The amount was gauged two years. The country is moor, partly flat, and partly precipitous, 20 miles from the west coast of Lancashire.

In 1846-7 the author conducted an experiment by accurately gauging for four months the water, flowing from 3,800 acres, into the Glencorse Reservoir, in the Pentland Hills, belonging to the Edinburgh Water Company, as follows:—

	Cubic Feet.	Inches.
1846, December.—Supply into Reservoir ...	19,762,000	=fall of rain 1.43
,, ,, ...	Registered ditto	1.02
1847, January.—Supply into Reservoir ...	14,524,200	=fall of rain 1.05
,, ,, ...	Registered ditto	.75
,, February.—Supply into Reservoir ...	18,637,100	=fall of rain 1.34
,, ,, ...	Registered ditto	1.56
,, March.—Supply into Reservoir ...	9,662,520	=fall of rain .69
,, ,, ...	Registered ditto	1.02

The total rain passing into the Reservoir in four months being ... 4.53
Ditto registered in rain gauges at level of Reservoir ,, ... 4.31
,, ,, ,, on the Hills ,, ... 4.75

Again in the Bonally district adjoining, but about 500 feet higher than Glencorse, we found the mean run of the streams to be 112 cubic feet per minute, or equal to a fall of rain over 879 acres of 4.55 inches, the registered fall being as before 4.71 inches.

As a contrast to the foregoing table, we now offer a second:—

TABLE OF ORDINARY SUMMER DISCHARGE

of various rivers, streams, and springs, as uninfluenced by any immediate rain; with the drainage area, and amount run off the surface represented in depth of rain.

RIVERS.	Height above Sea. Valley	Height above Sea. Hill.	Drainage Area.	Total Discharge.	Discharge per Square Mile.	Representing Rainfall per Annum.	Total average Rainfall per Annum.
	ft.	ft.	sqre. miles.	cubic ft. pr. min.	cubic ft. pr. min.	inches.	inches
Thames at Staines—chalk, greensand, Oxford clay, oolites, &c.	40 to 700		3,086	40,000	12.98	2.93	24.5
Severn at Stonebench—silurian	400 to 2,600		3,900	33,111	8.49	1.98	
Trent at its mouth—oolites and Oxford clay	100 to 600		3,921				
Loddon (Feb. 1850)—greensand	110 to 700		221.8	3,000	13.53	3.01	25.4
Nene, at Peterborough—oolites, Oxford clay, and lias	10 to 600		620.0	5,000	8.45	1.88	23.1
Mimram, at Panshanger—chalk	200 to 500		50.0	1,200	2. 4	5. 5	26.6
Lee, at Lee Bridge — chalk (*Rennie*, April, 1796)	30 to 600		570.0	8,880	15.58	3.53	
Wandle, below Carshalton—chalk	70 to 350		41.0	1,800	43. 9	9.93	24.0
Medway, driest seasons (*Rennie*, 1787)—clay	..		481.5	2,209	4.59	1.04	
Ditto, ordinary Summer run (*Rennie*, 1787)	..		481.5	2,520	5.23	2.19	
Verulam, at Bushey Hall—chalk	150 to 500		120.8	1,800	14. 9	3.37	
Gade, at Hunton Bridge—chalk	150 to 500		69.5	2,500	36. 2	8.19	
Plym, at Sheepstor—granite ...	800 to 1,500		7.6	500	71. 4	15.10	45.0
Woodhead Tunnel—millstone grit	1,000		...	139	...	...	46.0
Glencorse Burn ... ... (*e*)	750 to 1,600		6.0	130	21. 6	4. 9	37.4
Crawley Spring—felspar and porphyry—Summer (*e*)	556 to 1,600		.6	54	90. 0	20. 2	,,
,, Winter (*e*)	,,	,,	.6	77	128. 3	29. 0	,,
Blacksprings—felspar—Sum. (*e*)	1,000 to 1,600		.1	30	300. 0	70. 0	(*c*)
,, ,, Winter (*e*)	,,	,,	.1	40	400. 0	92. 0	(*c*)
Bavelaw—sandstone—Summer (*e*)	900 to 1,600		1.42	120	84. 5	19. 0	(*c*)
Colzium ,, ,, (*e*)	,,	,,	4.20	113	29. 9	6.87	(*c*)

The examples here given have generally been corroborated by our own observations; the rain at the places marked (*c*) has not been kept, but that at Glencorse represents the rain for the lowest point of the same district; the rain on the hills is much greater.

The Blacksprings among the Pentland Hills indicate a drainage from a district apparently far beyond the water shed; they occur at a protrusion of basalt; these springs and others marked (*e*) are from gaugings made at different periods, under the provisions of Acts of

Parliament, for the protection of parties having water privileges. The locality is a point which must collect much rain from its peculiar situation.

The Wandle, Verulam, and Gade, all flowing out of the chalk towards the metropolis, are from Mr. Telford's gaugings made in 1833, a period which he terms "the driest season known for the last half-century;" but there is reason to believe that this was not the time of the minimum discharge.

The table gives the run of the several streams per square mile of drainage area, which is an excellent measure of their productiveness, and we have likewise reduced the amount (as supposed to run uniformly during the year, irrespective of floods) into the quantity distributed over the drainage area, as fed by rain; for example, the summer run of the Thames is stated at 12.98 cubic feet per minute for each square mile, representing a rate of 2.93 inches of rain falling over its drainage area, while the summer run of the Mimram is 24 cubic feet per minute for each square mile, representing nearly six inches in depth per annum, if the rate were uniform for that period.

ESTIMATE OF FLOODS.

In a paper by Mr. Mulvany, one of the Irish Commissioners of Drainage, are the following facts as to floods in the Shannon, which we have put into form, shewing the fractions of an inch of rain, distributed over very large drainage areas:—

Lough Allen is a reservoir of... ... 8,852 acres.
Drainage area being ... ... 146 square miles.
Floods rise frequently 3 ins. in 24 hours = .284 inches rain over the whole basin.
Less frequently 4 ,, ,, = .379 ,, ,,
And sometimes 6 ,, ,, = .568 ,, ,,

Lough Derg, above Killaloe, is ... ... 30,313 acres.
Drainage area of Shannon, above Killaloe, being 3,611 sq. miles.
,, ,, of the immediate basin of L. Derg 960 ,,

Total 4,571

This Lough, before the improvements of the Shannon,

Rose frequently	3 ins. in 24 hours	= .148 ins.	run off, or	225 c. ft.	per sq. ml.
Less frequently	4 ,, ,,	= .190 ,,	,,	310 ,,	,,
About once in each yr.	6 ,, ,,	= .296 ,,	,,	480 ,,	,,
17th November, 1840	12 ,, in less than 24 hours	= .600 ,,	,,	960 ,,	,,

The register of the rise of this flood in Lough Derg, is as follows:—

	Gauge.	ft.	in.
1840, November 13th, to		9	8
to the 16th, when rain began ...		9	9
17th, ...		10	9
18th, ...		11	1
19th, ...		11	3
20th, ...		11	4
21st, ...		11	4
22nd, ...		11	8
23rd, ...		11	9

Among other examples may be quoted those by Mr. Robert Manning, C.E., of the Irish Board of Works, who gives the following cases of floods which were observed in the arterial drainage works, the chief of which were in the northern and western parts of Ireland, with considerable area of mountain country :—

Number of Examples.	Drainage Area.	Max. discharge per Square Mile.	Max. Fall of Rain in 24 Hours.
	Square Miles.	Cubic feet per minute.	Inches.
1	3,690	282	
4	1,170 to 1,560	358 to 429	1.75
2	470	531	1.75
3	234 to 280	531 to 640	1.49 to 1.75
4	110 to 140	461 to 717	1.20 to 1.83
3	98 to 100	544 to 890	0.80 to 1.20
2	45 to 60	800 to 1,158	0.80 to 1.30
1	46	1,568	2.00
1	35	2,688	2.00

This accurate observer gauged the Glyde river, during a very wet period, from the 13th of December, 1850, to the 13th of March, 1851; the river has a basis of 124 square miles. The following were the results :—

1851	Mean flow per Square Mile.	Depth run off Basin.	Rainfall observed.	
	C. ft. pr. m.	inches.		
January 13th	160	3.04	2.02	Maximum discharge was 461 cubic feet per minute per square mile. Minimum discharge was 52 cubic feet. Low Summer discharge was 20 to 24 cubic feet.
February 13th	240	4.56	3.43	
March 13th	95	1.66	0.44	
Total ...	165	9.26	5.89	

These results are similar to the winter experiments in the Pentlands (*ante*), when the quantity running off was more than the observed rainfall; in this case the ratio is as 1.57 to 1.00. The discrepancy arises in these cases, undoubtedly, from the great excess of rain falling on hill slopes above the locality of the rain gauges. The rainfall of this period was excessive. (See Tables of Rainfall—Division IV.)

The months of December, 1850, and January, 1851, gave 3.55 and 6.33 inches of rain at Castlebar, Co. Mayo; and other places in the West of Ireland had from eight to nine inches in January; the flow off the surface of the basin of the Saleen, Castlebar, Manulla, and Robe rivers was gauged by Mr. F. Barry, C.E., at 5.73 and 8.33 inches off the surface during the respective months; the total area of the four basins being 200 square miles. The quantity appears excessive; but we have the warm Atlantic in full effect in producing rain in the *West* of Ireland, although the *East* of that country is nearly as dry as the East of England.

In the Saleen district, the maximum flood in January was 960 cubic feet per minute per square mile, and there was a flow of 640 feet for nine days; the same quantity flowed by the Castlebar river for seven days, by the Manulla for four days, and the Robe for one day. These differences must have been greatly due to varying intensity of rain.

Mr. Mulvaney, C.E., states that the ordinary floods of the Woodford river (Leitrim and Cavan) give 426 cubic feet per square mile, and the following is given by this gentleman as the greatest discharge measured during the very high floods of January, 1851 :—

	Area of Basin.	Quantity run off Basin per square mile.	Depth run off in 24 hours.
	Square Miles.	C. feet per min.	Inches.
Lower Erne at Belbeek	1522	333	.206
Upper Erne at Belturbet	483	534	.331
Woodford River at Ballyconnel	140	721	.447

Mr. Barry quotes an experiment made by him on the 16th of July, 1850, in the Lannagh district, where, by gauging the Lough, it was found that .53 inches ran off the surface (30 square miles) between the 16th and 20th of July, from rain which fell to the amount of 1.83 inches in twenty-four hours on the 16th, there having been no rain for nine days previously. This quantity must have been accurate, from being gauged in the lake which was dammed up at the time; the rise from the 16th to the 17th was .244 of an inch off the drainage area. In two other districts of twenty-four square miles, the quantity run off in three days from the 16th of July, 1850, represented about one inch in depth.

At page 153 and 154 will be found more particular information on the comparative rainfall and flow from the Ballinrobe and Ferbane districts in the West of Ireland, and from the district of the lower Bann when issuing from Lough Neagh in the north of that island; in this latter case the flow is regulated by the lake, but the basin has a much more mountainous character than the former rivers, although the rainfall at equal elevations is less in the north than in the west of Ireland.

In the clay and lias formation of Northamptonshire, where the hills do not exceed 500 feet above the sea, rainy seasons cause endless floods: we have an experiment, made between the 21st and 23rd of May, 1849, on the River Nene, at Higham Ferrars; this place is intermediate between the water-shed and Peterborough, being distant about twenty-five miles from the water-shed all round the west and north sides.

The drainage area above Higham Bridge is 383 square miles. On the 20th of May about one inch of steady continuous rain fell, raising the stream from its ordinary run of about 5,000 cubic feet per minute, to a quantity averaging about 32,000 cubic feet per minute, lasting from the evening of the 20th to that of the 23rd, when the river, in the course of a very short time, relapsed into its usual state. Dividing this quantity over the drainage area, we shall find that there flowed off the ground about .156 or just three sixteenths of an inch—thus the proportion flowing off the ground was about one-sixth of the rainfall. In this example it must be recollected that the weather was beginning to be warm, and the flooding of meadows along the valley would have absorbed at least

three inches in depth, which would represent about 1-16th of an inch more of rain having come down into the valley. The floods on the Nene have frequently twice, and sometimes three or four times, this volume; but in exceptional cases ten times the above volume may be assumed as the maximum flow.

In the Pentland Hills, on August 8th, 1846, a storm, giving 1.88 inches in the gauge at Glencorse, produced for four hours a run of 24,180 cubic feet per minute; this amount from 3,820 acres, would be equal to .437 or nearly 7-16ths of an inch of rain off the surface in this short time. Probably more than this came down, as the reservoir had to be filled before the flood passed over the weir used for gauging. This is an indication of the violence of the celebrated Lammas flood of this date, which washed down several of the bridges on the North British Railway, situate on rivers flowing from the steep hills skirting the east coast of Scotland.

Mr. Bateman records an experiment near Bolton, where on a drainage area of 5,400 acres, 5 inches were measured in the rain gauge, having fallen during eight consecutive days previous to the 10th of June (the end of May having been very wet); the flow of water had passed off entirely by the 12th of the month, when a quantity of water was found to have fallen equal to 4.625 inches in depth over the drainage area. This flood is exceeded frequently by twice and three times the volume.

Mr. Bateman also describes the heavy floods from January 1st to February 9th, 1848, when 11.5 inches fell, of which 6.4 inches fell in the nine days of February, three of the days (the 4th, 5th and 8th) giving 1.1, 1.2 and 1.3 inches. These returns are from an average of many rain gauges placed in the Longendale district, which is moorland, and from 500 to 1,800 feet above the sea, and about 45 miles therefrom. The area is 29.5 square miles, and the mean discharge was 713 cubic feet per minute per square mile for 40 days, or .44 of an inch per diem run off the surface during the whole period. At Rhodeswood reservoir the maximum flow in 24 hours was 46,000 cubic feet per minute off 11.2 square miles, or 4,100 cubic feet per square mile, which is equal to 2.4 inches off the whole surface.

During this severe flood on about 25 square miles, part of the same district, 6.5 inches flowed of the surface in 5½ days of February, 1848, or 1.2 inches per diem; this is equal to about 2,000 cubic feet per minute per square mile.

These cases are extremely different to those in districts where the rainfall is small and the soil permeable, for instance:—

Mr. Glynn considers that for draining fen districts more than ten horses power per 1,000 acres is seldom required, the water being lifted about ten feet. Two inches per month is about the maximum rainfall requiring to be discharged; assuming this quantity to be thrown at a rate of 500 cubic feet per minute, a ten-horse engine will perform the duty in about 232 hours.—*Paper on Steam Drainage of the Fens.*

Mr. Roe states that he measured and drained off to one outlet 82 acres of *meadow land,* and made observations on the flow for six months; the greatest amount found to reach the drain from a fall of half an inch of rain in the hour, was three cubic feet per minute per acre at the period of greatest flow, which was generally from three-quarters to one hour after the heaviest rain.

For more detail on volume of floods see the pages in the section devoted to Rivers, &c.

DIVISION OF FLOOD WATERS FROM ORDINARY DISCHARGE.

While upon the subject of floods it will be interesting to quote the substance of a paper by James Leslie, Esq., of Edinburgh, Civil Engineer, read before the Institution of Civil Engineers in April, 1851, as follows:—

It is frequently a problem to ascertain by gauging the average flow of a stream during a part of the year, exclusive of flood-waters; it being difficult to assign any fixed time when a stream is and when it is not in a proper state for gauging, as it would require a knowledge of the very fact which it is wished to ascertain; moreover, persons must be found frequently to gauge for many months together, without discretion as to what should be excluded, and sometimes stated intervals are named in an Act of Parliament. Mr. Leslie therefore proposes the following method:—

First.—The gaugings are all to be set down in a table, in the *order of their quantities*—the whole number of observations is to be divided into four equal parts, whereof the lowest fourth will be held to be *extreme droughts*; and the highest *floods*; the average of the middle half is to be ascertained, and all above that quantity of the original table is held to be flood-water.

A new table is then to be constructed, in which all the gaugings not exceeding the average of the middle half are put down at their actual quantity; but all that are above the average are put down as equal to that average quantity; the mean of the whole of the new table is to be considered as a fair average of the water flowing in the stream, exclusive of floods. Mr. Leslie gives a table of a stream thus treated, which varied in its run from 1,902 to 59,861 cubic feet per minute. Average of the whole was 10,231 cubic feet per minute; the average of the middle half was 7,234 cubic feet per minute; and the average quantity, exclusive of floods, was 5,830 cubic feet per minute.

Mr. Leslie also suggests that his plan might be used by dividing the gaugings into only three equal parts, which gives a rather smaller result, but makes no important difference; the above stream treated in this manner gives the average of the middle third 7,085 cubic feet per minute; and the quantity, exclusive of flood-water, 5,758 cubic feet per minute. An example is also given of a small stream varying from .27 to 272.4 cubic feet per minute.

	Cubic feet per minute.
The entire average was	35.50
Average of middle half	18.51
,, ,, third...	17.90
Final average, excluding floods by middle half plan ...	13.65
,, ,, ,, by middle third plan ...	13.40

TABLES OF FLOW FROM LARGE DISTRICTS THROUGHOUT THE YEAR.

ON THE RIVER LEE.

The Lee and branches take their rise among hills of gentle inclination, with flat summits about 250 to 350 feet above the sea. The total area, above its junction with the Thames at Blackwall, is 700 square miles, but its more important feeders cease at 16 miles from the Thames, where the basin is about 500 square miles, and 100 feet above the sea: below this point there are clay lands on one side of the valley; and faults which cut off the chalk beds occur on the opposite side, so that in dry periods there is but little additional visible feed to the valley. This small river is well known for its pure sources in the tertiary sands and chalk hills of Hertfordshire; hence it has always been a favourite water for the supply of London, and it is owing to the Thames having a similar source for a large proportion of its volume that it bears such a high character as a pure potable water. One of the branches of the Lee has such great beds of sand and perennial springs, that the heaviest rains will not produce a flood in a strict sense. It is not uncommon for many months to pass without a sensible discoloration of the Lee water by floods.

The author has gauged this stream for eleven years past, and the monthly returns for 1851, 1852 and 1856, are given in the "Tables of Discharge from Large Districts."

Reference to these tables will afford much information, for their general results are applicable to the Thames and the Seine, or like rivers in these latitudes, having due regard to the difference of the areas and elevation. The quantities run off per square mile are very similar (see Table of Rivers), and at least half of the area of the Thames and Seine is of permeable, tertiary and cretaceous rocks, like those of the Lee. The rainfall of the Thames is rather higher than that of the Seine or the Lee, and the impermeable lias district at its head is more subject to the western rains from the Atlantic. The Seine head is granitic and mountainous compared with that of the Thames.

The deep-seated springs of the River Lee are probably affected by rain at an interval of a year after its fall; for instance, the wet year of 1860 kept up a full summer supply through 1861, although this year was hot and dry; again, the hot summer of 1861 was followed by a dry autumn, and yet, although an average of five inches of rain fell in November, the river was scarcely affected; so little that one and a half inch of rain in the first week in December scarcely produced turbid water, and in the first week in January, 1862, the flow was lower than it had been since September, 1859. The largest of the lower springs from the chalk, at the end of December, was still at its lowest of the year: this is not uncommon with springs in districts of chalk and green sand with overlying drift: in the absence of recent heavy rains affecting the upper beds, it may be doubted whether the real minimum of these springs is not between October and December, and the maximum between May and July. Generally speaking, all round the metropolis the deep springs are situate at from 190 to 120 feet above mean sea level: in fact, there are few that exist below this level, for the waters appear to issue silently beneath the upper beds of drift into that of the valley, where the water is found very copious, as shewn by the quantity which has to be pumped in deep valley foundations. When the chalk springs are 140 feet or upwards above sea level, they generally have a more fluctuating character, unless they have

high land for a continuous distance above and around them. In 1851, 1854 and 1858, for instance, when the rain varied from 10 to 20 inches, many of the large upper springs were very low or ran dry: a very important one in Hertfordshire, situate about 150 feet above the sea, was dry from August or September to November or December of these years, although its discharge from December to July is rarely less than 130 feet per minute. On the other hand, those placed about 100 feet above the sea, and nearer to the base of the hills, are absolutely perennial. The following statement of a spring thus placed will shew the difference of character assumed by the lower position of a perennial one, flowing out of the drift beds deposited in clefts of the chalk, or apparently from the chalk itself. The mean discharge between September 1st, 1859, and June 1st, 1860, was about 280 feet per minute. By the 1st of July, 1860, the volume had increased to 340 feet per minute: this appeared to be the normal flow until August 18th, 1861. The quantity began to fall off from this date until the end of November, when the flow had again fallen to 280 cubic feet per minute. Although this was a very wet month, it certainly had no sensible effect on the spring; for being followed by a dry December, it appeared at the end of first week in January, 1862, the flow had fallen to 240 cubic feet per minute. By examining the rainfall of these years, its slow but steady influence on the springs will be traced.

The following table gives some of the discharges of the Wandle, at Wandsworth, and Colne, above Uxbridge. The Wandle has a large area of dry streamless chalk hills, forming the major portion of the basin, and its waters have almost more strictly a deep-seated chalk spring character than those of the Lee, the discharge of which, during parallel seasons, is given as a means of comparison. The Colne basin is remarkable for a considerable district of table land with depressions, having no outlet for flood waters, excepting by "swallows."

DATE.	River Wandle 54 sq. miles.		River Lee, 444 sq. miles.		DATE.	River Colne, 300 sq. miles.		River Lee, 444 sq. miles.	
	Discharge 1844.	Discharge per sq. mile.	Discharge 1851.	Discharge per sq. mile.		Discharge. 1855.	Discharge per sq. mile.	Discharge. 1855.	Discharge per sq. mile.
	c. feet pr.min.	c. feet pr.min.	c. feet pr.min.	c. feet pr.min		c. feet pr.min.	c. feet pr.min.	c. feet pr.min.	c. feet pr.min.
August 18th.	3,050	56.5	8,204	18.5	April 22nd ...	5,996	20.0	6,062	13.6
Sept. 2nd	3,192	59.1	6,663	15.0	May 6th	4,234	14.1	6,120	13.8
,, 9th.....	3,168	58.7	6,547	14.7	,, 18th.....	5,277	17.6	6,359	14.3
,, 16th.....	2,880	53.3	6,551	14.7	,, 23rd	5,819	19.4	6,151	13.8
,, 23rd.....	2,809	52.0	6,370	14.3	June 6th	6,373	21.2	6,341	14.3
,, 30th.....	2,695	49.9	6,405	14.4	,, 16th	5,996	20.0	5,811	13.1
October 7th..	2,832	52.4	7,207	16.2	Sept. 1st.....	4,923	16.4	4,663	10.5
,, 14th..	2,803	51.9	6,500	14.6	,, 22nd ...	4,234	14.1	4,698	10.6
,, 28th..	3,170	58.7	6,559	14.8	Dec. 8th	8,978 1856	29.9	9,655 1856	21.7
					Feb. 23rd	11,204	37.3	12,483	28.1
					June 20th	11,204 1857	37.3	10,015 1857	22.5
					March 7th ...	10,050	33.5	9,955	22.4
Average	2,955	54.7	6,779	15.27	Average	7,024	23.4	7,359	16.6

The River Colne, in Essex, was gauged near Halstead, for 24 hours, on the 6th and 19th of August, 1859, and gave a discharge of about 2.16 cubic feet per minute, per square mile, for its 41 square miles: the dis-

charge of the Lee at the same time was about 11 cubic feet per minute, per square mile. The district has a low rainfall, and the summer was decidedly dry; the soil is drift clay, gravels, sands with chalk beneath at considerable depths, the beds of which probably dip away from the valley: the contrast of flow is very great.

It is very difficult to test the flow from small districts of cretaceous formations in relation to their area of supply, especially where springs alone are concerned; the large spring above quoted *would appear* not to have more than 1.3 square miles of contributing area, so that a mean flow of 300 cubic feet per minute would require 53 inches of rainfall per annum: as the mean rainfall is not half this depth, it is clear that the collecting area must be far greater than is apparent on the surface.

AS TO FLOODS OF THE LEE, AND SIMILAR PERMEABLE DISTRICTS.

With years having only 18 to 22 inches of rainfall there are scarcely any real floods in these rivers, in this climate; when the rainfall is from 22 to 28 inches the floods are generally frequent, or if the district is of such permeable character that there are no floods (such as on the Wandle and Colne), then the perennial supply is copious; if, again, the annual rainfall increases from 30 to 40 inches the floods are constantly recurring: on the Lee, for instance, in 1860, there was rarely a month passed without two floods.

Notwithstanding the placid flow of the rivers deriving their supply from chalk and deep permeable drift, these basins of permeable formation have occasional floods almost equal to those of mountainous districts.

In the south-east of England, north of the Thames, there has rarely been a period more rich in floods than November, 1852; in this month six inches of rain fell at Greenwich, and nearly eight inches in the Lee valley, following a September of 4 inches and October of 6 inches fall. The rain at Feilde's weir for November was about 2 inches on the second, and of the remaining six inches about 3 inches fell between the 10th and 15th of November, and about 2 inches between the 20th and 27th. The total flow off the ground for this month was 2.32 inches in depth, excluding a considerable quantity not gauged. These rains, with those of 1857 and 1860, are described in the tables devoted to Rainfall. The floods committed serious damage from the Severn and Trent to the Thames, and laid the lowlands of Cambridgeshire, Norfolk, Suffolk, and Essex under water, for several weeks in many cases.

The floods on the Lee in November, 1852, were excessive, and the maximum rain committed great mischief; this was, however, exceeded in intensity by the floods of October 23, 1857, within a few days of which date the extreme floods occurred on the southern slopes of the Alps, and in the Ardèche on the Cevennes Mountains. (*See River Po.*)

A description of the storm will be found given by Mr. Glaisher in the 1858 report of the Meteorological Society. The rainfall at the centre of the district up to 9 a.m. of the 17th of October, 1857, had amounted to 1.32 inch; on the 18th it was .18; on the 19th, .20; on the 20th, .10; on the 22nd, .50; and finally at 9 a.m. on the 23rd, 2.55 inches fell, when the storm ceased, and on the two following days .15 and .10 only fell. In short, the rainfall causing this flood was over one-tenth of an inch for 36 consecutive hours, as recorded: but the centre of the storm was near the head of the valley, and is thought to have been even more heavy in that district. At about 2 a.m. in the morning of the 23rd, the flood began to surmount every bank and barrier in the large flat space below Hertford,

which receives the waters of the four branches of the Lee; this was filled to a depth of about 4 to 6 feet by 7 a.m., from which time up to midday the flood was at its height at Ware; at Rye Mead, about four miles lower down, the waters rose so high that the ordinary wide opening on the Eastern Counties Railway, which here crosses the valley, became a secondary passage for the waters, which assumed a direct course through two small flood openings. The flood carried away the entire structures at about 8.30 a.m., and the scour was so great as to have made pools 12 to 16 feet deep in the peat and ballast at the points of rupture. The maximum head of this flood passed down the Lee Valley to the Thames' mouth, a distance of 22 miles, in about 32 hours, giving an average velocity of 62 feet per minute. The author gauged the velocity of this flood at its maximum, at Ware Bridge, through which point the major portion of waters were compelled to pass. The width of opening was 45.5 feet, and depth about 11 feet; area 510 square feet, and observed velocities gave a maximum of 825 feet and an average of 768 feet per minute (*see Flood of the Loire*). The discharge was thus 391,680 cubic feet per minute for an area of 300 square miles, giving 1305.6 cubic feet per minute, per square mile, or .81 inch run off the entire surface in 24 hours; this full flow was only attained for about 12 hours, but as there was a large quantity during the entire day making its way by forced passages, on the New River and down the line of railway (which became a floodway), it is considered that the above estimate of flow is not excessive. The gaugings at Feilde's weir (440 square miles) between the 22nd and 26th gave a flow off the ground of 142 cubic feet per square mile, being .44 inches for the five days, or .088 per diem, but adding the extreme flood of the 23rd, it is probable that the total flow off the ground was 1.162 inches, or a mean flow of .281 inch per diem, for five days, being 450 cubic feet per minute, per square mile, which is an extreme case for so low and flat a district. An independent computation of another kind gave the mean flow for 24 hours at Feilde's weir of the 23rd October, at .835 inch run off, or 1347 cubic feet per minute, per square mile. The intensity of this flood had no precedent within memory or record, and therefore its volume affords a highly interesting record. This flood did not perceptibly affect the Thames, because that river did not receive much of the storm; but the memorable rains of November, 1852, raised high and low water of the Thames upwards of three feet on the 19th and 20th of that month, the tides being affected to this extent by the gorging of flood waters.

The rains of November, 1852, were copious and widely diffused, being far above the average all over England, throughout the seaward parts of France, and over the Jura and Alps from Dijon to Milan; they prevailed in a similar manner in North America and in Germany, but in some few cases October is the wet month instead of November.

The storm of October, 1857, was centrical and concentrated at the various points where it was severe, in Italy, France, and also in England, where its centre was about Royston, and a radius of 30 miles would include the heavy and remarkable portion of the storm, viz., *an average fall* of one-tenth of an inch per hour for 36 consecutive hours. The great rains of May 27th to 30th, 1856, which deluged the Loire, Saône, and Rhone valleys, appeared to concentrate on the Puy de Dôme and Jura ranges; it was not so great on the head of the Rhone or the Po.

In May, 1856, the rain was 7.3 inches at St. Bernard; 11.7 at Geneva; 9 to 12 in the valley of the Saône; as far west as Dijon the fall was 8.3 inches; but at Paris the rain was only the usual amount. May, in England was generally very wet, *i.e.* nearly double the average: this was the case also at Madras and Calcutta. (See Division IV.)

HINXWORTH EXPERIMENTS.

Mr. J. Bailey Denton, C.E., has lately read a paper at the Institution of Civil Engineers, wherein observations over 12 months in 1856-7, of the actual discharge from free and tile-drained soils (amounting jointly to 200 acres) situate at Hinxworth, near Tring, amounted to about 7.5 inches off the surface, while the rain-fall was about 21 inches, the average being 24 inches.

The following more precise experiments were made during eight months from 1st of October to 31st of May, 1857 :—

Month.	Rainfall.		Water percolated or run off.			
			No. 1, 2, 3.	No. 1.	No. 2.	No. 3.
	Rainfall each Month.	Quantity the Rain would represent per acre.	Mean of flow from all Experiments	46 acres, Chalk with Clay, Gravel, or Sand, Greensand and Gault Clay. Drains 174 feet apart and 4 feet 4 inches deep.	42 Acres, Soil partly as last column, but more Gault Clay with Lime. Drains parallel and wide apart.	29 Acres very stiff Gault Clay. Drains 25 feet apart, and 4 feet deep.
			Quantity run off per acre.	Quantity run off per acre.	Quantity run off per acre.	Quantity run off per acre.
	Inches.	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.
October...	1.645	37,215	5,818	12,910	4,546	
November	1.630	36,872	10,458	27,000	4,046	330
December	1.235	27,935	16,768	30,565	13,915	5,825
January .	2.333	52,775	39,943	43,855	44,170	31,805
February .	.192	4,343	16,801	27,360	13,985	9,060
March ...	.820	18,547	6,188	8,415	6,840	3,310
April.....	1.440	32,586	7,865	6,683	10,725	6,188
May	.750	16,967	3,819	4,132	3,907	3,418
Total...	10.045	227,240	107,660	160,920	102,134	59,936
Over surface	= 10.045 ins.		=4.7 ins.	=7.1 ins.	=4.5 ins.	=2.65 ins.

By the above it would appear that in November, December, January and February, the tendency of percolation is to approach the amount of rain fallen during the same period, but that in the eight months the quantity run off was about 4.7 inches out of 10 inches that had fallen. This result is tolerably consistent with the Dalton gauge experiments, for the quantity run off is nearly that due to the year of low rainfall; and all experience shews that very little more would have filtrated during the four months of June to September. The tables of the River Lee experiments on 440 square miles of drainage area, which affords practically nearly all percolated water, excepting in floods, are singularly consistent with these experiments on an area of only about the 2,500th part of the Lee. See also numerous other experiments and gaugings quoted in this Division.

TABLES OF FLOW.

This will be a suitable place for referring to the subsequent tables of the flow of water from several considerable districts, which have been taken out with great care and much labour, by the gentlemen who have assisted in this treatise.

The tables will be found to give the maximum floods, with the mean and maximum discharges, and respective rates of flow from the several basins, taking the square mile of 640 acres as the unit, computing the discharge and treating such afterwards as if it were distributed in uniform depth over the whole surface from which it is supposed to have flowed; the observed rainfall at the nearest station is then set out in each case and made the standard of comparison.

The several articles on the Rhone, Arve, Loire, Po, Rhine, Nile, &c., which follow these tables, contain computations from the most trustworthy records at present available on this somewhat untrodden branch of engineering science.

General information on the rainfall is given for each locality; but more particulars will be found in the tables of rainfall, Division IV.

It must be borne in mind that the localities vary greatly in latitude, mean temperature, climate, geological structure, elevation and slope; it is for this reason that we have been at some pains to procure examples rather than attempt to propound theories; but in order to throw light upon the question, the reader will find in Division IV. some records of evaporation combined with the temperature and rainfall for several places in this country and in the tropics, compiled and computed from the best observations that could be procured.

The table of the River Lee is from gaugings taken, twice a day, over a tumbling bay, constructed with the object of ascertaining the constant flow of water. (See Art. "River Lee.")

The tables of flow from Loch Katrine, Loch Lubnaig, and the Brockburn, are derived from Mr. Bateman's reports on the supply of water to Glasgow; and partly from Mr. Leslie's gaugings. The data for the Lower Baun and Brosna-Ferbane rivers were most kindly furnished by Mr. Forsyth, C.E., of the Irish Board of Works. This gentleman has had great experience in arterial drainage and other works touching the subject which we are now discussing.

The table of discharge gauged in 1851-52, from the Robe district, in the North-west of Ireland, is from a paper by Mr. Betagh, C.E., given to the Irish Institution of Civil Engineers, and kindly forwarded to the author by this gentleman, who has been at much labour in these investigations.

The gaugings from which the flow of the Tiber is computed, were furnished by Secchi, the learned astronomer,* at Rome, with other information on the rainfall.

The mean height of this river from 1822 to 1849, as recorded by Venturoli, is shewn on a diagram (plate XIV., fig. 5), with the mean monthly rainfall *at Rome;* the curves indicate much feed from snow collected in the winter, which, however, evidently melts early

* It is gratifying to acknowledge the immediate assiduity with which eminent scientific gentlemen holding the observatories of St. Petersburgh, Rome, Naples, Madrid, Brussels, &c., have responded to applications for information. The international Post Office arrangements now render correspondence easy and cheap, where formerly it was practically impossible to procure prompt returns.

in the year, owing to the comparatively small heights of the mountains at the sources of this river. The heights are given for a minimum year, 1834, and maximum years, 1822 and 1836. The monthly rainfall at Rome from 1822 to 1849 will be found in Division IV.; but it must be assumed that the precipitation of the hill country, forming the basin of the Tiber, is far greater than these returns indicate. The springs are said to be very great in volume, owing to the cavernous nature of the rocks. Lombardini states that the section of the Tiber, at the lowest period of 1834, was 230 feet in breadth, with a mean depth of 8.4 feet, and a mean velocity of 177 feet per minute. This would give a discharge of 342,000 c. feet per minute, and about 53 c. feet per square mile, which seems high for such an exceptional year. It is probable that the stated velocity is very much in excess; but this great authority regards the minimum volume of the Tiber to be triple that of the Po, area for area.

Below the table of this river will be found the quantity of water used, and area of land irrigated in the plains of Lombardy referred to in the article "River Po."

The Saône river is one of peculiar character, inasmuch as it makes a complete circuit round both flanks of the Jura mountains, and receives very heavy rains, accompanied by melting of snow in May and June, and rain only in October and November. The summer droughts are long and sometimes severe, so as much to impede navigation.

The table of discharge of this considerable river is from returns published by the Hydraulic Commission of Lyons. These highly valuable gaugings were made for ten years, accompanied by strict meteorological observations kept at twelve stations. The essence of the experiments (from 1852 to 1855) is given in the table, and the bearing of the temperature, combined with the rainfall and melting of snows on the volume of the river may be distinctly marked. In reference to this subject, the diagram fig. 4, plate XIV., may be noted as shewing the volume of the Seine, the Po and its tributary the Adda, compared with the rainfall and temperature. This diagram is from Lombardini's researches; it has no scale, and is, therefore, probably relative only; but a reference to the "Table of Rivers" at the end of this Division, will give the mean, maximum, and minimum discharge of these examples, and thus afford a key to the curves of variation. On plate XIV. fig. 5, we have also given a diagram of the variations of the Tiber, and rainfall for the years above described.

For the rainfall in all these cases, see Division IV., where also will be found the details of stations in the Rhone and Saône Basins; see "Rainfall of France—Bourbonne to Besançon," &c.

Further information on the flow of large rivers will be found under the articles on the Po, Nile, Rhone, &c., &c., which form the sequel to this division of the treatise. We have added some gaugings of districts, artificially drained by sewers, and amount of water supplied by the great water companies over the large area forming the metropolis of this country.

DETAILS OF FLOW FROM LARGE DISTRICTS.

RIVER LEE, HERTFORDSHIRE.

DISCHARGE AT FEILDE'S WEIR.

Drainage Area 444 square miles; Height of District from 80 feet to 500 feet above the Sea; Mean 240 feet. Length of Main River 31 miles, of Tributaries 92 miles above the Weir; which is above 20 miles from the Thames at Blackwall.

Year 1851.

MONTH.	Mean Temp. at Greenwich.	Rainfall.			Discharge over Feilde's Weir.			Discharge per Square Mile.	Depth run off District.	Proportion of depth run off to depth fallen.
		No. of Days.	Max. Days' Rain.	Total.	Maximum	Minimum	Mean.			
	Deg. Fah.		in.	in.	Cubic ft. per Min.	Cubic ft. per Min.	Cubic ft. per Min.	Cubic ft. per Min.	in.	1 to
Jan.....	42.9	18	1.10	3.65	83,080	7,227	23,198	52.2	1.04	3.51
Feb. ...	40.1	12	0.40	0.90	29,641	10,367	14,868	33.5	0.58	1.55
March.	42.6	20	1.22	4.35	95,677	9,448	28,582	64.5	1.24	3.51
April...	44.7	14	0.56	1.80	38,565	11,384	15,682	35.3	0.66	2.73
May ...	50.9	10	0.30	0.76	21,216	8,887	11,207	25.2	0.48	1.58
June...	58.9	11	0.50	1.45	11,217	6,455	8,678	19.5	0.36	4.03
July ...	60.1	16	1.55	2.92	10,930	6,235	8,000	18.0	0.30	9.73
Aug....	62.3	8	1.05	2.33	8,562	5,569	6,894	15.5	0.30	7.77
Sept....	56.9	9	0.36	0.63	6,669	4,508	5,814	13.0	0.24	2.63
Oct....	52.6	12	0.45	2.15	8,108	4,473	6,260	14.1	0.27	7.96
Nov....	37.9	10	0.40	1.10	7,342	4,753	6,290	14.2	0.26	4.23
Dec.....	40.4	6	0.50	0.58	8,126	4,660	6,127	13.8	0.27	2.15
	49.2	146	1.55	22.62	95,677	4,473	11,800	26.6	6.00	4.26

Year 1852.

Jan.....	42.0	16	2.20	4.67	79,469	5,260	19,912	44.8	0.86	5.43
Feb. ...	40.8	10	0.60	1.48	40,957	9,305	14,575	32.8	0.59	2.51
March.	41.3	3	0.30	0.35	9,880	6,158	8,065	18.2	0.35	1.00
April...	45.9	2	0.56	0.94	8,226	5,102	6,722	15.1	0.28	3.36
May ...	51.5	12	0.48	1.76	7,571	4,865	6,429	14.5	0.28	6.28
June...	56.1	21	1.02	4.35	44,695	4,929	9,804	22.1	0.41	10.60
July ...	66.6	4	1.03	3.15	14,436	4,760	6,432	14.5	0.28	11.25
Aug....	62.1	15	0.65	4.08	29,098	4,890	9,717	21.9	0.42	9.71
Sept....	56.8	13	1.20	4.02	63,214	5,405	13,823	31.1	0.58	6.93
Oct....	47.9	15	1.60	5.22	91,744	9,011	27,614	62.2	1.19	4.39
Nov....	48.9	22	1.80	7.30	106,795	18,699	55,341	124.6	2.32	3.15
Dec.....	47.6	19	0.55	2.39	66,707	23,323	36,273	81.7	1.57	1.53
	50.6	152	1.80	39.71	106,795	4,760	17,892	40.3	9.13	4.35

Year 1856.

Jan.....	39.4	18	0.55	2.35	69,428	9,225	24,345	54.8	1.05	2.24
Feb. ...	42.0	10	0.45	1.30	60,420	10,060	16,829	37.9	0.68	1.91
March.	38.7	6	0.70	1.00	15,167	8,669	10,246	23.1	0.44	2.27
April...	46.8	13	0.60	2.00	22,935	7,555	9,944	22.4	0.42	4.76
May ...	49.5	18	0.77	3.60	47,031	7,533	12,235	27.5	0.53	6.80
June...	55.2	7	0.30	0.65	13,963	7,399	9,264	20.9	0.39	1.66
July ...	61.1	13	0.72	2.25	8,792	6,009	7,529	16.9	0.32	7.03
Aug....	63.6	10	0.80	2.60	6,047	5,266	5,759	13.0	0.25	10.40
Sept....	55.2	7	1.05	2.80	11,312	4,119	5,851	13.2	0.24	11.66
Oct....	51.7	10	0.25	1.90	12,030	4,958	6,634	14.9	0.29	6.55
Nov....	40.7	10	0.40	1.40	20,056	5,969	7,849	17.7	0.33	4.24
Dec.....	40.2	12	0.40	2.05	64,902	6,242	14,500	32.6	0.63	3.25
	48.7	134	1.05	23.91	69,428	4,119	10,915	24.6	5.57	4.29

DETAILS OF FLOW FROM LARGE DISTRICTS.

LOCH KATRINE DISTRICT.

Drainage Area 71.6 square miles, Precipitous; 400 to 2,500 feet above Sea.

1854.	Discharge from Loch Venechar.					Rainfall at Glengyle.	Proportion Run off to Rainfall.
	Maximum.	Minimum.	Mean.	Mean per Square Mile.	Depth Run off.		
	C.ft. per min.	C.ft. per min.	C.ft. per min.	C.ft. per min.	inches.	inches.	1 to
January...	102,000	4,000	29,300	409	7.9	12.0	1.52
February	80,000	24,000	41,500	580	10.1	9.5	0.95
March ...	48,000	23,000	31,200	436	8.4	7.4	0.09
April	26,000	7,000	14,000	195	3.6	2.6	0.72
May	17,000	7,000	12,700	177	3.4	8.8	2.60
June	58,000	8,000	22,800	318	5.9	9.4	1.60
July	57,000	11,000	23,000	321	6.2	4.7	0.76
August ...	36,000	12,000	18,500	258	4.9	6.7	1.37
Sept.	22,000	8,000	14,300	200	3.7	6.1	1.65
October ...	150,000	14,000	27,500	384	7.4	12.2	1.62
Nov.	60,000	15,000	29,800	416	7.7	5.7	0.74
Dec.	87,000	22,000	49,500	649	12.5	18.2	1.46
			26,167	362	81.7	103.3	1.26

LOCH LUBNAIG DISTRICT.

Drainage Area 69.7 Square Miles, similar to that of Loch Katrine.

1846.						Mean.	
Dec.			7,133	102.3	1.97	1.95	0.99
1847.							
January...			13,070	187.5	3.60	4.05	1.13
February.			15,113	216.8	3.76	3.84	1.02
March			13,316	191.0	3.67	3.51	0.96
April.....			14,356	206.0	3.83	6.47	1.70
May			24,887	357.1	6.86	5.86	0.86
June			5,855	84.0	1.56	3.06	1.96
July			6,174	88.6	1.70	3.83	2.25
August ...			12,864	184.6	3.55	5.02	1.41
Sept.			12,321	176.8	3.29	5.22	1.59
October...			28,460	408.3	7.85	11.54	1.47
Nov.....			34,936	501.3	9.32	12.35	1.32
	Maximum flow not recorded.	Minimum flow not recorded.	15,691	225.7	50.96	66.70	1.31
1854.							
January...	172,000	3,000	51,700	742	14.3	8.2	
February.	130,000	12,000	54,000	775	13.4	5.2	
March ...	100,000	8,000	35,700	512	9.8	5.0	
April.....	51,000	3,000	12,600	181	3.4	1.5	
May	26,000	6,000	14,200	204	3.9	6.0	
June	114,000	6,000	33,000	473	8.8	7.8	
July	57,000	6,000	23,200	333	6.4	5.3	
August ...	64,000	5,000	24,000	344	6.6	4.7	
Sept.....	36,000	3,000	14,000	201	3.7	4.3	
October ...	328,000	9,000	47,000	677	12.9	10.1	
Nov.....	82,000	9,000	27,000	387	7.2	4.3	
Dec.	205,000	22,000	77,000	1,106	21.3	12.1	
			34,400	494	111.7	74.5	

The preceding Column gives the Mean Rainfall as shewn in the Table of Rainfall in Loch Katrine District: it appears, however, to be less than the depth run off.

BROCKBURN, GORBALS WATER WORKS, GLASGOW.

District 4.3 Square Miles; 400 to 800 feet above Sea, with Store Reservoir.

1852.							
January...			2,257	525.1	10.10	10.00	0.99
February.			1,868	434.0	7.80	6.05	0.78
March ...			393	91.4	1.76	1.02	0.58
April			387	90.0	1.67	0.70	0.42
May			315	73.3	1.41	3.55	2.52
June			341	79.3	1.47	4.35	2.95
July			467	108.6	2.08	7.65	3.68
August ...			368	85.6	1.64	4.47	2.73
Sept.			377	87.7	1.63	1.00	0.62
October ..			380	88.4	1.70	2.38	1.40
Nov.			900	209.3	3.89	7.35	1.89
Dec.			2,741	637.4	12.25	11.90	0.97
	Maximum flow not recorded.	Minimum flow not recorded.	900	209.2	47.40	60.42	1.27

DETAILS OF FLOW FROM LARGE DISTRICTS.

RIVER BANN, AND LOUGH NEAGH, IRELAND.

DISCHARGE OVER THE NEW WEIR BELOW THE LOUGH.

Area of Lake 153 sq. miles; Drainage area 2,052 sq. miles; Total 2,205 sq. miles. Summer level of Lake 46 feet above the Sea: Height of District 46 feet to 1,035 feet and 1,765 feet—one-third of the Mountains bounding the district being upwards of 1,000 feet above the Sea.

Year 1856.

MONTH.	Rainfall at Armagh.			Discharge over Toome Weir.			Discharge per Square Mile.	Depth run off District.	Proportion of depth run off to depth fallen.
	No. of Days.	Max. Days' Rain.	Total.	Maximum	Minimum	Mean.			
		in.	in.	Cubic ft. per Min.	Cubic ft. per Min.	Cubic ft. per Min.	Cubic ft. per Min.	in.	1 to
January ...	20	0.35	2.26	464,900	279,000	360,000	163.2	3.13	0.72
February ...	17	0.67	2.27	621,000	279,000	434,100	196.9	3.54	0.64
March	9	0.25	0.75	379,000	133,800	208,600	94.6	1.81	0.41
April	15	0.24	1.05	211,000	109,000	142,400	64.6	1.20	0.87
May	18	0.47	3.01	198,300	69,800	120,300	54.5	1.05	0.29
June	22	0.32	2.09	172,500	96,300	144,200	65.4	1.21	1.72
July	21	0.23	1.49	125,600	69,800	95,500	43.3	0.83	1.80
August	15	0 66	2.69	125,600	69,800	91,600	41.5	0.79	0.34
September .	19	1.12	3.49	235,200	69,800	91,800	41.6	0.77	4.53
October	13	0.34	1.49	293,500	142,600	211,800	96.0	1.84	0.80
November...	19	0.64	1.47	222,800	96,300	147,700	67.0	1.25	1.17
December...	18	0.92	3.86	662,400	186,200	401,800	209.4	4.02	0.94
	206	1.12	25.92	662,400	69,800	209,150	94.8	21.44	1.28

BROSNA, FERBANE, RIVER.

DISCHARGE AT FERBANE BRIDGE.

Drainage area 446 sq. miles; Height of District from 152 feet to 650 feet and 1,054 feet. Mean 288 feet. Length of Main River above Ferbane Bridge 38 miles, of Tributaries 90 miles—Total 128 miles.

Year 1852.

January.....	23	0.58	5.89	127,000	18,200	64,258	144.1	2.77	2.13
February ...	18	0.76	4.37	238,400	48,800	120,473	270.1	4.87	0.89
March	11	0.50	1.17	51,700	25,600	35,084	78.7	1.51	0.77
April	8	0.56	1.09	33,400	13,700	19,543	43.8	0.81	1.35
May	12	0.60	2.42	29,700	9,200	17,035	39.6	0.77	3.14
June	26	0.81	6.15	79,500	8,800	38,939	87.3	1.62	3.80
July	10	0.81	2.38	44,900	17,300	26,690	59.8	1.15	1.98
August	19	0.70	4.11	28,600	15,700	20,316	45.5	0.87	4.72
September .	11	0.25	0.95	19,700	8,300	12,147	27.2	0.51	1.86
October.....	18	0.30	2.09	25,400	9,400	13,487	30.2	0.58	3.60
November...	23	1.45	6.27	188,800	26,600	96,937	217.3	4.04	1.55
December...	26	0.63	4.51	155,000	61,500	110,481	248.2	4.77	0.94
	205	1.45	41.30	238,400	8,300	47,999	107.6	24.27	1.86

Year 1856.

January ...	22	0.63	3.16	91,500	42,300	69,500	155.7	2.99	1.06
February ...	14	0.67	2.03	97,200	36,900	62,900	141.2	2.54	0.80
March	4	0.26	0.51	39,600	20,600	28,600	64.2	1.23	0.04
April	14	0.37	2.16	74,900	20,600	31,100	69.7	1.30	1.66
May	18	0.74	4.75	113,700	19,800	49,400	110.7	2.13	2.23
June	15	0.44	2.01	45,600	23,500	33,100	74.2	1.38	1.46
July	18	0.58	2.29	27,500	18,200	21,500	48.1	0.92	2.49
August	15	0.43	2.26	23,500	15,900	19,000	42.6	0.81	2.79
September .	26	0.78	2.95	91,500	15,900	23,600	53.0	0.99	2.98
October.....	12	0.67	1.95	82,200	27,500	39,600	88.8	1.71	1.14
November...	16	0.33	0.80	42,300	22,600	25,900	58.1	1.08	0.73
December...	19	0.88	4.28	166,000	21,500	79,600	178.4	3.42	1.25
	193	0.88	29.15	166,000	15,900	40,300	90.4	20.50	1.42

NOTE.—The Mean Temperature of the Latitude of Armagh for 1856 was about 46 Fah.
" " " Ferbane " " 48 "
That of Greenwich having been ..... 48.7 "
The details of the Temperature at Greenwich during the years 1852 and 1856 will be found in the table of River Lee Discharge.

DETAILS OF FLOW FROM LARGE DISTRICTS.

RIVER ROBE, MAYO, IRELAND.

DISCHARGE AT BALLINROBE.

Drainage area 70,000 acres=109.4 square miles; Height of District 100 to 370 feet; Mean 180 feet above the sea; Character—Flat, and one-tenth bog or low land, the remainder clay and sand, overlying porous limestone rock; Length of Main River 33 miles. Rainfall for 1851, registered at Cong, 6 miles outside district; for 1852 at Farmhill, near centre of district. Height of rain gauge 256 feet above the sea; results of gauges on 16 months' comparison closely agree. In January, 1851, 3.41 inches fell in one week, and the greatest day's rain was .90 inches; in December, 1852, 3.17 inches fell in the same period, and the greatest day's rain was 1.06 inch.—(*Betagh; Proceedings Inst. Civ. Eng. Ireland*, 1853.)

Year 1851.

MONTH.	Rainfall.		Discharge at Ballinrobe.			Discharge per Square Mile.	Depth run off District.	Proport'n of depth run off to depth fallen.
	No. of Days.	Total.	Maxim'm	Minimum	Mean Dischrge.			
		inches.	Cubic ft. per Min.	Cubic ft. per Min.	Cubic ft. per Min.	Cubic ft. per Min.	inches.	1 to
January	27	9.20	85,836	20,133	43,373	395.5	7.61	1.20
February	14	6.80	72,448	18,420	30,410	278.0	4.82	1.41
March	24	4.40	49,137	10,860	20,945	191.4	3.68	1.19
April	17	3.50	24,200	5,760	14,355	131.2	2.44	1.44
May	12	0.90	5,820	4,125	5,001	45.7	0.88	1.02
June	13	3.90	7,040	1,114	4,230	38.7	0.72	5.41
July	17	3.95	4,920	1,500	2,558	23.4	0.45	9.00
August	10	2.30	17,055	1,240	4,866	44.5	0.86	2.67
September	7	1.95	4,746	1,200	2,854	26.1	0.49	4.00
October	24	4.80	23,980	6,940	12,588	115.1	2.22	2.16
November	15	1.30	12,852	6,000	7,827	71.5	1.33	0.98
December	8	2.60	44,715	6,210	14,373	131.4	2.53	1.03
	188	45.60	85,836	1,114	13,615	124.4	28.03	1.63

Year 1852.

January	27	7.59	41,600	12,852	28,730	262.6	5.05	1.50
February	13	4.80	56,400	8,190	25,296	231.1	4.15	1.15
March	7	0.67	9,600	2,737	6,702	61.3	1.18	0.57
April	8	1.13	3,931	1,468	2,477	22.6	0.42	2.70
May	9	2.00	3,931	1,050	1,861	17.0	0.33	6.06
June	21	6.72	22,764	1,400	6,547	59.8	1.11	6.05
July	10	2.56	15,439	3,172	6,057	55.4	1.07	2.40
August	14	4.47	3,856	2,236	3,070	28.1	0.54	8.27
September	7	1.80	3,427	2,642	2,874	26.3	0.49	3.67
October	17	3.91	32,040	1,114	5,932	54.2	1.04	3.76
November	24	5.46	45,360	17,000	30,742	281.0	5.23	1.04
December	31	11.98	115,658	23,232	54,846	501.3	9.64	1.24
	188	53.09	115,658	1,050	14,595	133.4	30.25	1.75

DETAILS OF FLOW FROM LARGE DISTRICTS.

RIVINGTON PIKE, LANCASHIRE.

Area of District 16.25 square miles; Height above sea, from 900 to 1,525 feet; 20 miles from west coast: Character—Moorland, overlying carboniferous strata; Rainfall, average of a series of gauges occupying positions below the mean level of the water shed. In December, 1846, 8 inches fall; average Rainfall at Belmont for 1847 and 1848, was 63.6 inches; from 1843 to 1848, 57.6 inches. The District constitutes that now supplying the Reservoirs constructed for the Liverpool Corporation Water Works.—(*Vide Reports by Stephenson, Simpson and Newland.*) The rainfall and discharge for 1847 from the Longdendale District, near Manchester, is also given; the rain for 1847 and 1848 averaged from gauges varying in height from 500 to 1,750 feet above the sea.—*(Bateman, Trans. Manchester Literary and Philosophic Inst.)*

Year 1847.

MONTH.	Rainfall	Discharge.	Discharge per Square Mile.	Depth run off District.	Proport'n of depth run off to depth fallen.	Longdendale.		
						Rainfall	Depth run off.	Proport'n
	Inches.	Cubic feet per Min.	Cubic feet per Min.	inches.	1 to	inches.	inches.	1 to
January	2.35	2,251	138.5	2.66	.88	2.5	2.85	0.88
February ...	3.67	3,100	196.9	3.41	1.08	4.3	4.10	1.05
March	1.32	685	42.2	0.81	1.63	1.7	1.30	1.31
April.....	2.66	1,926	118.5	2.20	1.21	5.5	4.12	1.33
May	6.16	4,262	262.3	5.04	1.22	6.4	4.75	1.35
June.....	4.35	1,670	102.8	1.91	1.28	3.4	1.65	2.06
July	1.24	424	26.1	0.50	2.48	1.5	0.99	1.51
August	3.25	444	27.3	0.52	6.25	4.6	1.24	3.71
September...	6.17	4,585	282.1	5.25	1.17	7.6	5.12	1.48
October	6.01	4,459	274.4	5.27	1.14	4.9	5.67	0.86
November ...	5.45	3,733	235.9	4.38	1.24	5.9	6.25	0.94
December ...	7.55	5,749	353.8	6.80	1.11	6.9	8.55	0.80
	50.18	2,744	171.7	38.75	1.30	55.2	46.59	1.18

Year 1848.

January	2.95	2,401	147.7	2.84	1.04	1.5		
February	7.48	6,425	395.4	7.10	1.05	9.2		
March	3.77	2,824	173.8	3.34	1.13	4.9		
April.....	2.51	1,404	86.4	1.61	1.56	2.5		
May	1.88	394	24.3	0.47	4.00	1.5		
June.....	5.85	2,444	150.4	2.80	2.09	6.5		
July	3.78	1,713	105.4	2.02	1.87	3.9		
August	7.58	5,412	333.0	6.40	1.18	7.0		
September...	3.67	1,822	112.1	2.08	1.76	4.5		
October	6.76	5,070	312.0	6.00	1.13	7.5		
November ...	3.14	2,181	134.2	2.50	1.26	3.1		
December	3.87	3,333	205.1	3.94	0.98	3.5		
	53.24	2,954	181.7	41.10	1.30	55.6		

DISCHARGE OF THE TIBER AT ROME.

The following Table gives the mean annual flow of this River for 28 years, with the quantity per square mile, the actual depth run off the surface in inches, the comparative recorded Rainfall, taking a mean of observations at Rome and Perugia, and the ratio of the recorded depths fallen to that run off by the River, taking the former at unity. The drainage area of the Tiber is 6,458 square miles. Its district is mountainous, but free from snows, or glaciers, or lakes; floods rise very rapidly, frequently from 30 to 45 feet above summer level. Venturoli calculated its mean summer flow to be .6 of its mean annual discharge. The flood of 10th December, 1846, was about 562 cubic feet per minute per square mile, being equal to nearly ⅔ths of an inch run off in 24 hours. This is a very high rate for the district, being six times that of the mean annual rate of discharge.

(From observations by Venturoli and San Bertolo.—"Ann. of Math. and Phys. Science.—Rome 1860.")

Year.	Dischrge. at Rome.	Dis-charge per square mile.	Depth run off District.	Rainfall average of Rome and Perugia.	Pro-portion of Rnfall run off	Year.	Dischrge. at Rome.	Dis-charge per square mile.	Depth run off District.	Rainfall average of Rome and Perugia.	Pro-portion of Rnfall, run off.
	cubic feet per min.	cubic ft. per min.	inches.	inches.	Rain equal 1		cubic feet per min.	cubic ft. per min.	inches.	inches.	Rain equal 1
1822	517,554	80.14	18.08	26.92	.67	1836	701,405	108.61	24.63	30.93	.80
1823	645,234	99.91	22.54	31.60	.71	1837	730,541	113.12	25.52	29.50	.86
1824	525,521	81.37	18.45	34.80	.53	1838	832,518	128.91	29.08	36.50	.80
1825	482,467	74.70	16.85	28.89	.58	1839	600,746	93.04	20.99	36.00	.58
1826	597,621	92.53	20.87	38.45	.54	1840	543,523	84.15	18.98	21.38	.89
1827	719,890	111.47	25.15	53.70	.47	1841	636,370	98.53	22.23	30.74	.72
1828	508,594	78.74	17.86	31.21	.57	1842	654,230	101.30	22.85	30.97	.74
1829	589,413	91.26	20.59	32.90	.63	1843	661,586	102.44	23.11	25.65	.90
1830	628,508	97.32	21.95	28.00	.78	1844	673,688	104.31	23.66	33.45	.71
1831	530,317	82.11	18.52	27.57	.67	1845	887,070	137.36	30.99	39.95	.78
1832	484,508	75.02	17.01	24.28	.70	1846	719,570	111.42	25.14	36.83	.68
1833	552,330	85.52	19.29	31.48	.61	1847	703,259	108.89	24.57	30.20	.81
1834	413,540	64.03	14.44	15.02	.96	1848	693,720	107.42	24.36	26.19	.93
1835	528,936	81.90	18.48	35.04	.53	1849	545,287	84.44	19.05	21.45	.89
						Mn.	618,234	95.73	21.62	31.06	.70

WATER USED FOR IRRIGATION FROM THE ALPINE RIVERS.

The following Table shows the quantity of water used per acre for irrigating the plains of Lombardy, with the area watered, and the total quantity taken by artificial Canals from the several tributaries north of the Po.

(Baumgarten's Memoir.—"Ann. des Ponts et Chaussées.—1st. Series, 1847.")

Name of Tributary.	Quantity taken in cubic metres per second.	Area watered in hectares.	Quantity taken in cubic feet per minute.	Area watered in acres.	Quantity used per acre, cubic feet per minute.
Ticino	51.40	47,000	108,916	116,144	.937
Adda	100.55	111,760	213,065	276,175	.772
Brembo	8.50	10,950	18,011	27,059	.666
Serio	13.90	17,680	29,454	43,690	.673
Oglio	76.55	107,000	162,209	264,412	.613
Mella	12.10	14,520	25,640	35,881	.715
Clesia	23.00	29,900	48,737	73,887	.660
Mincio	14.00	8,600	29,666	21,252	1.396
	300.00	347,410	635,698	858,500	.740
Minor Canals	60.00	72,590	127,140	179,380	.709
Total	360.00	420,00	762,838	1,037,880	.735

The rotation of supply in the Milanaise varies from six to ten days. In the Cremonaise, where water is scarcer and the soil less permeable, the rotation is sixteen days. In the Milanaise, with a ten days' rotation, the allowance is a litre per second for each hectare of arable and meadow land (.854 cubic feet per minute per acre); but for rice grounds double, and in special cases much more is allowed.

The capital value of 42 litres per second (88.74 cubic feet per minute), or the "Milanese ounce," is 10,500 francs (£430) if supplied during the summer months only, and 12,200 francs (£488) if supplied during the whole year. The annual rent is 435 francs (£17. 8s.) for the summer season, and 523 francs (£20. 18s. 5d.) for the entire year. These prices are for a supply taken near the principal aqueducts; but where it is necessary to lead the water to great distances, the charges are increased, and in some cases even doubled.

DETAILS OF FLOW FROM LARGE DISTRICTS.

RIVER SAÔNE, FRANCE.

DISCHARGE GAUGED NEAR LYONS during the years 1852-3-4-5. Drainage area 11,551 square miles; Length of Main River 180 miles; Principal Tributaries 422 miles; Height above Sea 605 feet at Trévoux; Mean Height of Rain gauges 1,080 feet; Crest of Jura Mountains 2,300 to 3,600 feet. General District of Main River 800 to 1,200 feet.

Month.	Mean Temp.	Rainfall Average of 12 Stations.			Discharge at Trévoux.			Mean discharge per Square Mile.	Depth run off.	Ratio of depth run off to Rainfall.	Evaporation observed at Dijon.
		Days' Rain.		Total	Maximum.	Minimum.	Mean.				
		No.	Max.								
1852.	Fah.		in.	in.	Cubic ft. per Min.	Cubic ft. per Min.	Cubic ft. per Min.	Cubic ft. per Min	in.	1 to	in.
Jan.	39.4	26	0.27	2.34	2,198,602	313,648	1,192,720	103.3	2.0	1.2	...
Feb	37.2	23	0.36	2.25	1,901,957	819,310	1,242,064	107.5	1.9	1.2	0.47
Mar.	39.5	10	0.22	0.72	1,292,333	479,907	699,654	60.3	1.2	0.6	1.91
April	49.8	12	0.23	0.64	720,975	193,757	406,974	35.2	0.6	1.0	3.67
May	60.1	22	0.22	2.32	392,115	181,593	234,313	20.3	0.4	5.8	3.50
June	71.2	30	1.13	7.41	3,133,071	177,596	1,467,517	127.0	2.3	3.2	2.40
July	71.6	20	0.29	1.87	2,322,818	226,814	669,036	58.0	1.1	1.7	5.35
Aug.	62.8	27	0.99	8.70	3,112,764	247,944	1,912,879	165.6	3.2	2.7	3.00
Sept.	59.2	22	0.77	4.07	2,522,818	754,913	1,369,456	118.6	2.2	1.8	2.21
Oct.	50.1	23	0.41	3.22	2,467,445	530,774	1,000,155	86.6	1.7	1.9	0.35
Nov.	50.2	30	0.45	4.59	3,526,564	327,324	1,696,049	146.8	2.7	1.7	1.56
Dec.	44.8	23	0.33	1.60	3,687,902	907,567	1,739,160	150.6	2.9	0.5	...
	53.0	268	...	39.7	3,687,902	226,814	1,135,831	98.3	22.1	1.8	24.42
1853.											
Jan.	42.3	27	0.30	3.29	2,495,058	666,472	1,641,440	142.1	2.7	1.2	0.24
Feb.	33.4	22	0.31	2.28	1,885,456	520,499	866,125	75.0	1.3	1.7	0.32
Mar.	35.8	25	0.24	1.23	3,437,994	337,887	1,278,083	110.6	2.1	0.6	...
April	48.9	30	0.62	3.63	3,096,876	572,561	1,795,853	155.5	2.9	1.3	1.41
May	57.7	29	0.57	4.54	1,968,110	819,310	1,396,424	120.9	2.3	1.8	2.64
June	62.7	24	0.53	4.48	2,284,293	801,553	1,574,080	136.3	2.5	1.6	2.52
July	69.1	22	0.49	2.86	1,901,922	464,946	996,398	86.3	1.6	1.8	5.15
Aug	68.0	19	0.37	2.22	479,905	204,305	339,640	29.4	0.6	3.9	3.31
Sept.	59.5	20	0.55	3.70	1,592,835	231,005	746,401	64.6	1.2	3.1	1.46
Oct.	53.2	28	0.45	3.91	1,479,982	392,114	1,031,196	89.3	1.7	2.3	0.94
Nov.	41.9	17	0.38	1.01	984,986	392,114	576,850	49.9	0.9	1.1	0.43
Dec.	29.3	16	0.18	0.87	430,550	218,660	344,148	29.8	0.6	1.6	...
	50.2	279	...	34.0	3,437,994	204,305	1,048,638	90.8	20.4	1.6	18.42
1854.											
Jan.	34.3	17	0.25	1.34	1,547,271	247,944	672,262	58.2	1.1	1.2	Ice.
Feb.	32.5	22	0.12	0.89	1,435,789	469,724	904,141	78.2	1.4	0.6	0.55
Mar.	41.2	7	0.02	0.06	697,921	392,113	582,355	50.4	1.0	0.1	2.05
April	53.4	15	0.30	1.02	387,380	181,591	300,262	26.0	0.5	2.1	1.88
May	58.1	27	0.71	4.12	1,509,751	273,814	861,687	74.6	1.4	2.9	2.22
June	63.0	23	0.90	4.31	1,662,628	479,905	943,958	82.6	1.5	2.8	2.17
July	67.8	25	0.38	3.39	1,399,349	469,924	1,036,119	89.7	1.7	2.0	2.40
Aug	61.0	19	0.45	2.32	1,055,612	444,348	558,010	48.3	0.9	2.5	1.97
Sept.	60.1	6	0.06	0.09	269,474	95,639	165,666	14.3	0.3	0.3	4.35
Oct.	52.7	23	0.78	3.22	1,222,814	79,773	278,009	24.1	0.5	6.9	0.51
Nov.	39.9	25	0.48	3.53	1,755,838	406,411	764,017	66.2	1.3	2.8	0.04
Dec.	39.0	28	0.45	3.71	3,270,718	1,748,506	2,419,629	209.4	4.0	0.9	0.20
	50.3	237	...	28.0	3,270,718	79,773	790,510	68.4	15.6	1.8	18.34
1855.											
Jan.	28.9	19	0.21	1.19	3,260,295	359,287	1,236,284	107.0	2.1	0.5	...
Feb.	37.9	25	0.34	3.46	3,268,781	551,545	2,464,764	213.4	3.7	0.9	1.06
Mar.	42.1	25	0.31	2.23	3,825,450	174,086	2,544,506	220.3	4.2	0.5	1.02
April	48.9	14	0.32	1.14	2,198,624	572,560	1,164,167	100.8	1.9	0.6	3.08
May	57.8	25	0.25	2.64	1,392,702	455,047	664,328	57.5	1.1	2.3	2.32
June	62.8	19	0.41	2.73	953,499	322,679	594,990	51.5	1.0	2.8	3.23
July	67.8	27	0.36	3.46	819,310	396,878	594,339	51.5	1.0	3.6	3.15
Aug.	75.9	18	0.26	1.33	583,154	215,223	380,284	32.9	0.6	2.1	3.90
Sept.	61.2	19	0.72	2.89	991,328	206,041	545,484	47.2	0.9	3.3	2.01
Oct.	55.2	28	0.72	5.54	2,286,737	273,823	1,347,844	116.7	2.2	2.5	1.52
Nov.	39.9	17	0.28	1.29	1,780,363	520,500	1,024,651	88.7	1.7	0.8	1 52
Dec.	37.3	18	0.17	1.02	1,519,756	346,289	627,852	54.4	1.0	1.0	0.08
	51.3	254	...	28.9	3,825,450	174,086	1,099,125	87.0	21.5	1.7	22.89
Mean of 4 years.	...	259	...	32.6	...	...	1,018,526	86.1	19.9	1.7	21.02

THE ARVE.

This mountain torrent drains 772 square miles of perhaps the most precipitous and snow-bound district in the world; about 62 square miles out of the whole area, being covered with glaciers and eternal snows. During the summer months the Arve has a kind of tide from the melting of snow during the day; this is represented by an increased height of 1½ to 4 inches; the difference amounts to about 46,000 cubic feet per minute less flow at morning than at night near Geneva, during May and June, and half that quantity during July and August. The hours of sunshine give an effect of .46 of an inch melted off the 62 square miles in the former months, and half that quantity in the later months; this difference is owing to the snows on the lower slopes having melted off, and the area being thereby reduced.

M. Paul Chaix has written an excellent article on this subject, in which he gives the above facts, and reports certain careful gaugings made by him in 1856. The flow during that year was

1856.	Discharge C. feet per Min.	Dis. per Sq. Mile C. feet per Min.	Depth run off. Inches.
January	169,500	220	4.23
February	148,300	192	3.45
March	127,000	164	3.15
April	233,000	302	5.62
May	635,600	825	15.86
June	487,300	630	11.72
July	422,000	547	10.52
August	360,000	466	8.96
September	260,000	337	6.26
October	154,000	200	3.84
November	74,000	96	1.84
December	131,000	170	3.27
Mean and Total.	266,800	346	78.72

The mean daily flow off the whole surface therefrom was about .214 of an inch for every day in the year. The above rates for November and December were considered very low. The memorable rains of May, 1856, raised the flow from 203,000 to 1,270,000 cubic feet per minute, or 1,645 cubic feet per square mile, or a rate of 1.019 inch run off in 24 hours; but eight days' rain fell before the river reached this flow, and it fell in one day to nearly half of that quantity. The flow of the parallel district round the Lake of Geneva at the same date was 1,375 cubic feet per minute per square mile.

THE RHONE.

This river has several distinct characters when it is affected by rivers having a volume almost approaching its own in high floods; such are the Saône, Allier, Isère, Durance and other torrents from the slopes of the Cévennes and northern flanks of the French Alps. These circumstances, combined with the generally southward and seaward exposure of the Rhone valley, render it fearfully liable to periodic floods.

The fact of its area being composed of three, four or five distinct sets of mountain slopes render the liability to floods at one and the same time not so certain, this fact mitigates the effect of what would otherwise make it impracticable to maintain artificial works within its influence. The general area in which the City of Lyons stands is about twelve feet above ordinary water, which passes that city with great velocity—about 400 feet per minute. In the flood of 1856, the river was several feet deep in the streets, and the Saône and Rhone formed one level across the town. The heights of ordinary and flood waters between Lyons and the Mediterranean, with surface slopes in drought and flood, are tabulated at page 179.

Approximate estimates of the ordinary and flood discharge of the Lower Rhone, will be found in the Table of Rivers at the end of this Division.

The Rhone flows out of the Lake of Geneva clear and blue, and is immediately affected by the highly torrential waters of the Arve; but above the Lake of Geneva, the Rhone has very nearly the character of the Arve. At St. Maurice, above the Lake, for instance, on the 17th of May, 1843, during a snow flood, the discharge was 300 cubic feet per minute per square mile from an area of 1,840 square miles. The mean lowest height of the Lake of Geneva stands at "27.5 pouces" on the limnimetre, in the month of May, when the snows begin to melt; the discharge is then about 520,000 cubic feet per minute, or 173 cubic feet per square mile; in 72 days the lake rises to the mean of its maximum height in July or August, viz., 74 pouces. The discharge is then about 1,000,000 cubic feet per minute, or 333 cubic feet per square mile; the rise of the lake is 3.96 feet in the 72 days, and on the 208 square miles of the lake is equal to 222,000 cubic feet per minute for the whole time; if we add this to the mean flow, we have a total of 982,000 cubic feet per minute for the flow due to the rain, springs, and melting of the snows. The area of the basin is 3,000 square miles, so that the flow is 327 cubic feet per minute per square mile, shewing that a depth was melted off the whole area, including rain, of about .203 of an inch per diem for the 72 days, or about 14.6 inches of water off the surface; but as the snow area is but a small portion of the whole (probably not more than one-fifth) the actual snow melted off must be far greater, probably 4 inches of rain and 10 inches of water from melted snow in the 72 days.

The foregoing calculation is based upon a somewhat high rise in the lake; but, nevertheless, in 1846 the rise was from about 40 to 90 pouces, which gives results just one-fourth greater than those above quoted, and, in addition, the lake being on an average 14 inches higher, of course the flow out was considerably greater than this proportion, The mean of 15 years (1846-1860) gives the difference between May and August at about 30—62 pouces, which would give three-fourths of the quantity above detailed. This corrected quantity may be taken as a tolerably true mean of the combined flow from the whole area drained, viz., rain and springs and melted snow combined, or $14.6 \times .75 = 10.9$ inches run off the 3,000 square miles in 72 days, or .155 of an inch run off per diem. This is very consistent with the flow of the twin river Arve; for further notice as to quantity of snow melted per diem, see the "Arve."

The minimum flow from the Lake of Geneva is about 195,000 feet per minute, or 65 cubic feet per minute per square mile, which is equal to 14.3 inches in depth ran off per annum, if there were no more, than the minimum. The mean state, however, is about 216.5 cubic feet per minute per square mile, or 48.7 inches in depth per annum. The rapidity of the Rhone above Lyons is no less surprising than true, indicating a bed of large boulder gravel, which fact generally prevails when the river is not excavated in solid rock.

Vallées gauged the river below Geneva in its high state (82.5 pouces), when the mean velocity was 336 feet per minute, and the sectional area was then 3,035 square feet. The depth in this part was then about 14.5 feet, and the width 213 feet. As to flood of May, 1856, see "Floods of the River Po."

Another gauging at the American Bridge, by M. Paul Chaix, when the lake stood at 21 pouces on the limnimetre, gave 421,500 cubic feet per minute; the width being 456 feet; the mean depth 5.93 feet; and mean velocity of all portions of the section being 116 feet per minute.

The height of the Lake is taken daily at the Limnimetre on the Grand Quais, Geneva, and from the records we have computed the following table of flow:—

THE RHONE AT GENEVA.

The following Tables give the mean monthly height, and also the maximum and minimum state of the Lake of Geneva for 15 years, 1846-1860, with the computed flow of the Rhone therefrom, and depth.

MEAN—1844 to 1860.

	Height on Limnimetre.		Discharge.	Discharge per sq. mile.	Depth run off.
	Pouces.	E. inches.	C. ft. per min.	C. ft. per min.	inches.
January	24.64	26.26	465,000	155	2.98
February	25.09	26.74	475,000	158	2.74
March	24.22	25.80	460,000	153	2.94
April	28.49	30.36	535,000	178	3 31
May	34.32	36 58	625,000	208	4.00
June	46.64	49.70	765,000	255	4.74
July	59.35	63.25	900,000	300	5.77
August	62.59	66.71	925,000	308	5.92
September	52.64	56.10	836,000	278	5.17
October	37.33	39.78	665,000	222	4.27
November	29.26	37.19	550,000	183	3.40
December	25.79	27.48	485,000	161	3.10
Total Mean	37.40	39.85	649,500	218.5	48.24

MAXIMUM YEAR—1846.

	Height on Limnimetre.		Discharge.	Discharge pr. sqr. mile.	Depth run off.
	Pouces.	E. inches.	C. ft. per min.	C. ft. per min.	inches.
January	29.8	31.19	550,000	183	3.52
February	31.8	33.89	585,000	195	3.38
March	26.3	28.03	490,000	163	3.13
April	36.3	38.72	650,000	216	4.02
May	43.4	46.30	740,000	246	4.73
June	68.8	73.32	980,000	326	6.06
July	90.1	96.02	1,105,000	368	7.08
August	85.6	91.22	1,080,000	360	6.92
September	68.5	73.00	980,000	326	6.06
October	47.7	50.83	780,000	260	5.00
November	32.6	34.74	595,000	198	3.68
December	26.9	28.60	500,000	166	3.19
Total Mean	48.98	52.20	753,000	251	56.77

The only years from 1846 to 1860 which approach this are—1860, which gave a mean height of 42.94 pouces, equal to a mean flow of somewhat less than 55 inches off the basin; the next high year was 1855=42.61 pouces; next in order was 1853, when the lake stood at a mean height of 40.48 pouces, equal to a flow of somewhat less than 50 inches off the basin.

MINIMUM YEAR—1858.

	Height on Limnimetre.		Discharge	Discharge pr. sqr. mile.	Depth run off.
	Pouces.	E, inches.	C. ft. per min.	C. ft. per min.	inches.
January	13. 8	14.70	200,000	66	1.27
February	13.84	14.27	195,000	65	1.13
March	17. 4	18.84	320,000	106	2.04
April	25. 9	27.60	485,000	161	2.99
May	25. 7	27.38	478,000	159	3.06
June	30. 4	32.40	570,000	190	3.53
July	39. 4	41.98	690,000	230	4.42
August	44. 4	47.32	740,000	246	4.73
September	37. 2	39.64	665,000	221	4.11
October	29. 5	31.44	550,000	183	3.52
November	25. 9	27.60	485,000	161	2.99
December	29. 5	31.44	550,000	183	3.52
Total Mean	27.71	29.52	493,166	164	37.31

The next year above this was 1857—30.62 pouces, which is equal to a mean flow of nearly 48 inches; the next was 1854 =31.68 pouces.

THE LOIRE.

The upper or Roanne branch of this river derives its waters from the Puy de Dôme range of precipitous mountains in the Auvergne, and is consequently of great volume, and floods most seriously, especially in spring and autumn (May and October). M. Vautier gauged a flood at Pont de Fleurs, about 20 miles above Roanne, on October 18, 1846, when the section had 31 feet ~~greatest~~ depth, 510 feet top width, and 15,800 square feet of area. The fall was .009 per 1,000, or ~~47.52~~ feet per mile, and the velocity about 920 feet per minute. From these data it was computed that the flood gave about 14,830,000 cubic feet per minute, the maximum rise above summer level having been 46 feet; it appears that this height was taken at a narrow point in the valley, where the river could not greatly overflow its banks. The area of drainage above this point is about 2,200 square miles, so that the flood gives about 6,740 cubic feet per minute per square mile, which is equal to a flow off the entire area of 4.1788 inches in the day, supposing that this immense quantity had flowed during the entire 24 hours. Vallées considers that this should be reduced in the proportion of 73 to 50 for the true flow. The fall of rain at Montbuison commenced on the evening of the 15th and increased greatly during the night of the 16th; it lasted all day of the 17th, and only ceased at 6 a.m. on the 18th of October: during this time of 60 hours there fell 5.7 inches. As this place is not in the mountain district, it is probably far beneath the mean fall in the basin at the time. We should not be inclined to quote this case as possible, were it not for the very immense rainfall that has been occasionally registered among the Auvergne and Cévennes mountains; as, for instance, that observed at Joyeuse on the 9th of October, 1827 when 25.26 inches fell in 21 hours, and the rainfall of the month was 38.36 inches. (See Division IV.) The river Loire, both above and below Orleans, is subject to very serious floods, as, for instance, in May,—June, 1856, when all the lower part of the cities on this considerable river were under water for several days, and frightful damage ensued.

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In 1846, the Loire, at Orleans, rose 16 feet in one day. The flood having risen to 22 feet 3 inches on the nights of the 21st and 22nd of October, it was propagated in 36 hours afterwards as far as Tours, a distance of 71 miles, when it rose nearly to the same height, but, after a few hours, fell about 3 inches, and then again for six hours stood at about 23 feet 6 inches, in consequence of the filling up of the plain by the breach, after which the flood resumed its course.

Dupuit says that the Loire carries in great floods twenty-one millions of cubic feet per minute, and calculates that, by a breach of the banks in a great flood, the volume of water covered a plain of 34 square miles, an average depth of 6.56 feet in five hours, equal to a flow in addition of four millions of cubic feet per minute, making a total flow of twenty-five millions of cubic feet per minute.

It is noticeable that, although the flood here quoted was so great, yet, owing to the distribution of its waters over the valley, the mean advance or velocity of its head did not exceed 170 feet per minute.

In some confirmation of these statements we quote from a French author on the floods of the Ardèche, that the flood on the Doux (a river of the Ardèche), on the 10th of September, 1857, discharged into the Rhone 25.5 millions of cubic mètres in nineteen hours from a basin of 244 square miles; this is equal to 3,216 cubic feet per minute per square mile.

The drainage area and relative flow of the Loire will be found in the Table of Rivers.

THE RHINE.

Basin 73,000 square miles at Emmerich where the Delta commences. Length from the Alps to the Sea, 850 miles.

This river has a very distinct character from the Rhone or Po, which drain the seaward or southward slopes of the Alps, inasmuch as it receives the waters of a country having comparatively small rainfall after leaving the Lake of Constance and the junction of the Arve. The floods are also less sudden, for the floods of the Black Forest rivers and other feeders can frequently run off before the Swiss waters arise, and these latter floods would rather depend on melting of snows by warmth, than on rain. From a combination of these circumstances, the floods are not excessive, other than at rare intervals; but if these accidents combine, the results are terrible, for immense masses of ice are floated into the stagnant branches, which are thus choked throughout the immense embanked delta. This country, intersected by numerous rivers more or less artificial, forms Holland—part of Belgium—and an immense tract of submerged banks, now gradually forming into future area for polders.

It is not the object of this treatise to discuss the engineering particulars of this river; they are given in much detail by German and French authorities (Desfontaines, Wiebeking, and others,) and also in a paper by the late G. B. Wheeler Jackson, C.E., in the 1848 Minutes of the Institution of Civil Engineers. It is chiefly from this paper that we have procured the following table of the slopes in drought and flood heights, and other details.

It is mean water level when it stands at 4 feet 6 in. Arnhem Level; when the water stands 18 inches above this, the velocity at the Spyke Passage and Pannerden Canal has a velocity of about 214 feet per minute, with a depth of 13.6 feet at Spyke, and 8.6 feet on the Pannerden Canal; the Yssel has a depth of about 7.7 feet, and velocity of about 170 feet per minute. Of the branches into which the Rhine divides itself below Emmerich, the Waal is considered to take 68.3 parts and the Pannerden Canal 30.7 parts; of which latter the Yssel takes 5.5 and the Leck 25.2; this is taking the whole volume of the Rhine at 100.

The tidal character of the mouths of the Rhine is weak and inefficient, owing to the flat and shoal banks formed by the sandy mud of the Rhine floods: these both check the tidal wave, and also (although of immense area) they offer sufficient friction to prevent the ebbing of the waters. Amsterdam is an example of this; although the Yssel is level with Zuider Zee, which it joins by a great breadth of salt channel; yet the ebb of low tide is only a few inches, and the shipping is brought up to Amsterdam by the North Holland Canal, which is navigated by ships locking downwards at the Helder, and upwards again into the Yssel head of the Zuider Zee at Amsterdam.

The surface slopes, duration of tide, and other facts connected with the numerous tidal branches of the Rhine, are given in the paper before referred to. Their general character is sluggishness, excepting during floods, which are certainly far less on this river than on those which drain the southern slopes of the European mountains. The greatest flood damage was probably done at the breaking up of frost in January and February, 1799 and 1809; in the first case 1,300 square miles of the low countries were inundated, and the dykes were broken in 23 places. The heights of these floods are shewn on the table, with the relative mean and low state of the river. The height of top of dykes above ordinary water (Amsterdam Pile Level) is shewn by deducting the first column from the last, and thus the expected rise of high floods at the different places may be judged; the greatest floods appear to have risen from 12 to 14 feet above mean water, and the dykes are from 14 to 16 feet above the same level.

A proximate statement of the discharge and area of the Rhine will be found in the Table of Rivers.

DETAILS OF THE RHINE.

Depth of the Rhine in floods, in great droughts, and its mean state at the following places:—

Date.	Cologne.	Emmerich	Pannerden	Nymegen.	Arnhem.	Gorcum.	Vianen	Doerburg.
	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.
High Floods, 1799, Feb...	25.5	22.11	...	25.0	20.0	13.5	19.6	...
,, 1809, Jan ...	27.5	22.10	25.1	26.0	20.0	15.3	14.8	19.3
Drought, 1800	6.10	4.0	5.5	6.5	3.9	1.8	4.8	1.4
,, 1814, Nov. 24 ...	...	...	...	5.4	...	...	...	...
Mean Water, 1782 to 1810 .	9.1	7.10	9.1	9.8	7.5	3.2	7.8	5.1

Table of the Height above the Sea, width, slope, depth and velocity of the Rhine above Emmerich.

Place.	Hght. above Sea.	Width	Depth	Slope per Mile.	Velocity in feet per minute. Low.	Mean.	Flood.	Remarks.
	feet.	feet.	feet.	inchs.	ft. ℔ m	ft. ℔ m	ft. ℔ m	
Reichenau	3,880	230	...	...	...	...	...	
Lake Constance	1,316	...	...	...	...	...	...	
Basle	820	750	3 to 10	47	516	558	824	Navigation begins.
Strasburg.....	451	1,100	...	38	to	to	to	
Lauterburg	348	1,100	3 to 12	13.8	186	294	558	
Mannheim	302	1,200	5 to 18	13.8	...	...	...	Effective navigation
Mayence	240	1,400	5 to 24	10.6	...	...	...	with six feet draft.
Bingen	229	1,160	6 to 20	12 to 21.1	...	...	...	Rocky bottom.
Coblentz	198	...	...	9.5	...	...	...	Flood discharge in
Bonn	151	1,240	8 to 24	13.8	...	330	...	cubic feet per second,
Cologne.....	126	1,300	8 to 23	17.1	...	312	...	at Basle 165,000; at
Dusseldorf.....	95.7	1,300	7 to 70	14.4	...	...	...	Lauterburg 180,000.
Wesel	57.6	1,600	25to29	11.1	...	264	...	
Emmerich	42.3	1,400	9 to 15	8.7	211	...	...	

RHINE BRANCHES THROUGH HOLLAND.

	Place.	Level above Amsterdam Pile. H.W.	L.W.	Width at 5.8 feet.	Depth at 5.8 feet.	Slope at 5.8 Water	Slope at H. W.	Slope at L. W.	Top of Dykes ab A.P.
		feet.	feet.	feet.	feet.	inchs. ℔mile	inchs. ℔mile	inchs. ℔mile	feet.
Waal Branch.	Emmerich	42.33	...	...	...	7.8	...	...	58.0
	Nymegen	29.74	...	...	...	9.5	7.4	...	46.9
	Ochten.....	20.21	...	...	...	...	8.9	...	36.0
	Tiel	17.37	...	...	...	...	5.8	...	32.0
	Bommel (Tide).....	8.84	...	...	...	L.W.	7.0	...	25.5
	Woudrichem.....	...	5.11	3.7	...	3.1	...	4.2	5.7	18.0
	Gorchum	...	4.78	3.3	...	...	...	0.95	2.0	16.5
	Hardinvelt.....	...	4.46	2.3	...	...	...	0.68	5.7	16.0
	Dordrecht	...	3.93	-1.6	...	...	...	2.6	4.2	12.0
	Krimpen.....	...	3.42	-0.6	...	...	...	1.1	2.3	13.0
The Leck and Pannerden Canal.	Emmerich	42.33	...	...	...	7.8	...	...	...	58.0
	Pannerden.....	34.72	...	...	...	8.1	7.4	...	...	51.5
	Arnhem	29.09	...	...	604	7.3	8.1	...	...	44.5
	Wyk.....	14.92	..	...	...	...	5.8	...	...	28.5
	Kuilenburgh	12.00	...	...	...	...	5.7	...	...	24.0
	Vianen (Tide)	7.7	...	...	...	7.4	5.7	...	...	20.5
	Schoonhaven	...	4.2	2.4	...	...	...	3.3	5.1	17.3
	Krimpen	...	3.4	-0.6	...	...	...	0.99	3.5	13.2
	Rotterdam.....	...	2.8	-1.6	1,500	L.W.	...	0.47	1.8	11.5
	Briel.....	...	2.8	-2.1	5,190	12.0	...	3.9	...	13.6
Meuse Branch.	Grave	17.57	...	...	...	...	...	...	...	37.0
	Batenburg.....	14.90	...	...	...	6.0	3.0	...	...	33.0
	Fort St. Andries ...	12.22	...	...	...	...	1.6	...	...	26.6
	Krevekeur.....	8.78	...	...	...	...	4.2	...	...	23.6
	Heusden.....	6.25	...	...	...	L.W.	4.7	...	...	22.0
	Helvoetsluis	...	4.5	-2.8	8,870	25to37	...	1.5	...	22.0
Yssel Branch.	Arnhem	29.09	...	...	...	...	...	and	...	44.5
	Westervoort	30.73	...	...	...	...	...	flatter	...	45.0
	Doesburgh.....	21.72	...	...	320	4 to 5	7.9	...	...	33.4
	Zutphen	12.33	...	...	...	4 to 5	6.5	...	...	27.2
	Deventer.....	8.21	...	...	..	6.2	5.5	...	...	22.7
	Kampen (Tide) ..	...	0.94	-0.7	...	2.0 to 2.6	2.7	...	...	9.1
	Zuider Sea at Amsterdam ...	...	0.10	-0.4	...	4.0 to 3.5	1.6	...	...	6.0

CHARACTERISTICS OF THE RIVER PO, ITS BASIN AND TRIBUTARIES.

(See Plates XIII. and XIV.)

This great river has been the subject of study for engineers and philosophers for centuries—last, but not least, is Lombardini, to whom, in fact, we are indebted for these notes. The enormous extent of submergible lands traversed by navigable canals of the Po and protected by its embankments, which are required to withstand floods occasionally standing 16 to 20 feet above the lands for several weeks without intermission; the immense supply of water taken from its tributaries for irrigation, and their highly torrential character, render its maintenance a most costly national object with the states through which it may pass.*

The hill country ceases somewhat suddenly at the foot of the vast belt of mountains which surround and form the basin of the Po; and thence extend vast plains from 35 to 50 miles in breadth, in which the rivers have formed their beds, without sensibly altering the general regularity of the country. In an immense furrow in these plains, the actual bed of the River Po winds its course, with a very gentle fall, towards the sea.

There are thus two plains—one submersible (being below high floods), and the high plain, which floods never reach. It is to this high plain that the master dykes of the Po are rooted.

The high plain on the right bank commences at the Tanaro, and is broken by the ramifications of the Apennines, but again commences below Stradella, and has a breadth of 6 to 8 miles between Piacenza and Parma, and is about 12 miles wide at the latter place.

The low plain has but small dimension above the Tanaro, but below it is constantly widening, being 7 miles wide at Piacenza, 10 miles at Cremona, 16 miles at Casalmaggiore, 22 miles at Mantua, and 32 miles of width opposite Sequano. The high plain has, however, not always the same level above the lower one; for it gradually reduces itself towards the level of the lower one by a gentle fall, when it merges into the low plain, and all the country is below the level of high floods.

The great plain of the Po is formed of detritus from the Alps and Apennines down to the greatest depth to which borings have been taken, sometimes with regular and almost horizontal stratification, and at other times without order. The detritus gradually becomes smaller towards the sea. The general position of the main river has been established, when the opposing influences of the affluents have neutralized each other. The materials carried by the affluents govern the size of those carried by the main river at their mouths; thus, below the Ticino, the rivers from the Alps and Apennines convey small gravel and sand, with the exception of the Trebbia, which deposits flints and large gravel in the channel of the Po, the bed of which is, at this part, itself formed of small gravel and sand. (*See remarks in notice of the Nile, as to analogous circumstances.*)

The larger deposits of the Trebbia are cut through by the floods of the Po, and frequently carried down; but this action would tend to push the main river from Piacenza, and lengthen the course of the Trebbia. This has not occurred at all for 2,000 years, during which time the river

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* Compared with the Po valley, the fens of Wisbeach and Lynn, forming the delta of the Nene and Ouse rivers, do not require a fraction of the care or outlay in their protection, and yet we know the enormous capital which has been spent in this district. The tides and pastoral floods of England are far less difficult to deal with than the mountain torrents and snows of the Alps and Apennines. Absence of effective tide in the Mediterranean also is a drawback to drainage operations not felt in this country.

has been known to flow through this city; and Lombardini thinks that the deposits of flints and large gravel on the Trebbia have been only recently made by some disintegration of the mountains at its sources.

Several of the feeders with a granitic origin have great purity even in moderate floods, but others are constantly turbid from the steep and loose mountain slopes where the winter snows are deposited. The great lakes, of course, afford the most translucent water, as it is rarely that floods can affect them.

After having received limpid rivers from the lakes, the Po takes the character of a partially turbid river. Nature varies much in its course: in Piedmont it flows over large flats of coarse gravel; then successively over coarse and fine gravel, and finally sand, to the junction of the Trebbia; then on sand only, which becomes finer and finer; and, lastly, on mud in the delta. The sand-hills on the coast, nevertheless, shew that much sand must at times be carried into the Adriatic.

The high banks of the Po, formed by recent alluvium, are generally raised above ordinary floods. From the Ticino to the Oglio they are of alternate banks of clay and sand, in which the latter predominates, offering little resistance to the action of water. The materials of the bed, generally fine gravel and sand, are easily transported, and again deposited on the least diminution of velocity; an irregular course, great width, and numerous islets are the result. Below the Oglio clay predominates in the banks; in the bottom the materials are finer, more readily transported, and the displacing of the bed is more easy than the erosion of the banks; hence, the course of the river is more confined, of greater depth, and less variable.

At Turin the discharge of the river is less than that of some of its lower tributaries; but below the Dora Baltea, which flows from Mont Blanc, it assumes a more imposing aspect. Towards the Sesia, which drains Monte Rosa, the Po commences to widen out in its own alluvium, forming a great number of islets. Below Valenza it reunites in one channel, which is tortuous. Below the mouth of the Tanaro, a turbid river, it again widens out forming islets, and only again reunites near the Ticino into a single channel, which, except at the bend of St. Cypriano, is almost straight to the mouth of the Tidone. From thence it again becomes tortuous up to the Adda, owing to the large shingle brought down by the Trebbia. Between the Adda and the Oglio it widens a third time, with variable arms. Lower down the islets become fewer and smaller, and the waters are collected into a section more and more narrow and deep, as the sea is approached.

AS TO THE SURFACE, FALL, WIDTHS AND DEPTHS OF THE PO.

Plate XIII.—Gives a map of the Po, its affluents and delta, on which the principal embankments and canals are shewn; also a section from Monte Viso to the Adriatic. Plate XIV. has longitudinal sections of the Po, Adige and Reno, in which are represented the ordinary and flood levels.

The surface fall of the River Po, in ordinary water, is from 34 inches to 19 inches per mile, between the Dora and the Ticino; from 18 to 14 inches per mile between the Ticino and the Adda, and from 14 to 9 inches per mile, between the Adda and the Oglio. Between the Ticino and the Oglio the breadth at ordinary levels is from 330 to 660 feet, and in flood time from 1,600 to 5,000 feet; but when the minor dykes are

covered, the width of flood between the master dykes is from to 2,600 to 10,000 feet.

From the embouchure of the Oglio the ordinary surface fall is reduced to 8 inches, and lower down to 2.6 inches per mile; in this district the river is narrower, being 1,000 to 2,600 feet wide in ordinary floods, and in high floods 1,000 to 5,000 feet.

Between the Ticino and Oglio the Po is no longer fordable, for at low water the least depths on the shoals are five feet: in deep pools the depth being 30 to 33 feet, and where there are defensive works (groins) the depths are 50 to 55 feet. Below the Oglio the least depth is 6 feet; in the pools 30 to 37 feet, and when defensive works form obstacles, 77 feet of depth is attained.

The greater or less inclinations, suspended matter and cohesion of alluvium, all tend to influence the course and bed of the river. Above and below the mouth of a turbid affluent, the main channel becomes tortuous, and the slope diminishes; the windings take up a width of 20 times the breadth of the main channel.* (*See fig. 2, plate XIII.*)

The windings continually increase by eating away the concave side and filling up the convex with deposit to the level of ordinary floods, until a high flood cuts a more direct course, and forms islands of the pieces cut off. In some parts of the river where torrents enter, this operation is observed to take about 30 years; these cuts are frequent where the alluvium is low, and there are cases where the saving of distance has amounted to 16,500 out of 23,000 feet, and 23,000 out of 29,500 feet.

Lombardini states authoritatively that the mean depth of the Po at low water period has not altered materially from A.D. 1693 to A.D. 1813, certainly not more than 3 to 4 feet at any point.

THE TRIBUTARIES OF THE PO.

The Alpine Tributaries of this river are all highly torrential above the Ticino; and this character appertains to all the streams descending from the north flanks of the Apennines.

The Alpine affluents are known as limpid, turbid, and mixed, according to the lake through which they have passed, and the nature of their sources. The Ticino, like the Rhone above Lyons, is limpid; but the Adda and Oglio are mixed, owing to the junction of turbid streams below their departure from their lakes.

The Lacustrine rivers, Ticino, Adda, Mincio and Oglio, have their bed excavated to a great depth below the plain; but those which come out direct from the mountains without lakes, are almost at the level of, or occasionally above the plain, at the points where they issue from the hill country. (See sections of the Adige and Reno.) In other respects the general character of all these affluents partake of that of the Po.

The Lacustrine rivers have a much less inclination than the plain through which they flow, which is formed of the granite and porphyry detritus derived originally from the Alps; that is, these rivers are far more excavated in the high plain at their upper part than where they enter

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* Baumgarten says this is also the case on the Garonne, where the bed of the river is 656 feet wide, and the windings take a space of 13,000 feet; this proportion must vary greatly with the slope of the valley and materials of which it is formed.

the Po. Thus the Ticino bed is 100 to 130 feet below the plain near Lago Maggiore, and only 50 to 65 feet at Pavia; the Adda is 100 feet below the plain at Trezzo a Lago, and only 30 to 35 feet at Crotta, and 16 to 20 feet at Spinadesco, where it formerly flowed. The Oglio banks are also 50 feet below the plain at Soncino, and only 16 to 20 feet at Calvatone.

It is probable that this destructive character—this cutting down of the plain—may be due to the violent action of water, passing down too rapid a slope from the original surface of the plain, at the outlets from the lake, formed as the plain is of a moveable material. It is clear, both on hydraulic and geological data, that the plains were not originally formed by rivers, but more probably by vast glaciers or fields of ice, which filled up the hollows of the present lakes; for it is not easy to imagine that the lakes have been formed since the great plains; how they can have existed while the plains were being filled out, is not explicable to our mind, except upon a glacial, or other theory, of parallel character. Moreover, this view is confirmed by the fact that many of the smaller lakes have been manifestly formed by moraines projecting from spurs of the secondary Alps; on examining the spots where the drift beds, forming the commencement of the great plains, touch and actually repose against the older rocks forming the spurs or sides of ravines, it will be found that the surfaces of the rocks are invariably polished and striated, in the direction of the mountains towards the plains.

We make this digression, because the original formation, and after erosion, of rivers and their beds, involves the great questions of the slope, velocity, and power of moving waters, the limits of which, in the order of nature and physics, it is the object of this treatise to elucidate.

AS TO THE EMBANKMENT OF THE PO, AND EFFECT ON ITS LEVELS.

The great master-dykes are only occasional above Cremona, as will be seen on the map of the basin of the Po. Below Cremona, the river on both sides is entirely embanked in a continuous form up to the sea, being only broken at the affluents, where the embankments are returned on each side in a similar manner to those of the main rivers, until they are grafted into the high plains, where floods can no longer overflow them. The widths of flooded lands of the Po, between the great dykes, in round numbers are thus—

Below Cremona, 22,000 feet; near Santa Margarita, 20,000 feet; Isola Pescaroli, 12,500 feet; at the Taro, 11,200 feet; at Gussola, 16,500 feet; at Casalmaggiore, 8,250 feet; at Guastalla, 6,600 feet; between Guastalla and the Oglio, an average of 10,000 feet; at the Oglio, 6,600 feet; near Borgoforte, 3,300 feet; at the Mincio, 2,650 feet; between Ostiglia and Massa, they average 4,000 feet; from the mouth of the Tanaro to the sea (several branches), 1,000 to 1,650 feet.

The torrential tributaries of the Po are likewise embanked; but much greater width is afforded for floods, in proportion to the area drained, than on the main channel; this, of course, is a natural result of the increased speed with which the waters travel down, owing to the greater slope of their beds and propinquity to hill country; for instance, where the Lombardo-Venetian Railway crosses the Sesia, it has 1,650 feet between its banks, the drainage area being about 1,127 square miles; the Trebbia has 1,970 feet, with 242 square miles; the Adda 722 feet, with

338 square miles, including the Chiavenna and Ongina; the Taro 2,756 feet, with 804 square miles; and the Tanaro has 1,260 feet of width between its banks, where the railway crosses it, with 885 square miles of drainage area above that point.

The insubmergible or master-dykes, so called, because they are constructed with the object of resisting all floods, are from twenty to twenty-six feet wide at top, and the slopes vary from one and a-half to two to one, but they always now repair at slopes of two to one: the slopes on the land side are strengthened by a set off about sixteen to twenty feet wide, at about ten to twelve feet below the top.

The great dykes have attained their present perfection by constant repairs, and great amount of raising from time to time: and their breaches by floods have been less and less frequent since 1705, when the entire length of 50 miles below Cremona was destroyed; but since their subsequent restoration, this length has never been breached. After the flood of November, 1801, they were raised about 10 inches above that flood; later they were raised about 30 inches above the flood of December, 1807, and lastly, they were carried about 32 inches above that of October, 1812.

These floods were respectively 25.2 feet, 26 feet, and 26.8 feet above the lowest water at Pontelagoscuro, and the only floods which have risen higher since these dates, are those of November, 1839, and October, 1857, when the maximum height was 28.1 feet at the same place. (*See Table of Heights of Floods, page* 170.)

The embankments above Cremona are generally covered or broken through in high floods. It appears probable that the smaller width of the valley, combined with the fact of the rivers descending direct from the mountains without the intervention of lakes in this part of the Po valley, would render perfect embankment more difficult, while the protected lands would not afford an area of sufficient importance for the expense.

It will be seen that, owing to the great distance between the master-dykes, below Cremona, there is a reservoir for floods, which exercises much influence in controlling and regulating the flow, so that a width of only 1,000 feet is sufficient for the outlet at the lower end of the river; this is shewn by the fact that Lombardini considers the maximum flood discharge of the Po not to exceed 5,150 cubic mètres per second at Pontelagoscuro; whereas, at the same time, the flow of this river and its affluents combined, must have been equal to 15,000 cubic mètres pouring into the great breadth of flooded lands below the Ticino. This large quantity is equal to .75 of an inch depth over the entire basin brought down in 24 hours; but the actual flow was only, as above, about one fourth of an inch in depth.

These wide spaces between the insubmergible embankments offer considerable amount of land for pasture, and owing to deposits from floods, they are higher than the inner lands, protected by the great embankment. They are called "golenas" and are themselves protected by minor banks, made, and kept up at will, by the different proprietors, who are not permitted to raise them higher than about 5 feet below the top of the adjacent master-dykes. They have every kind of form and height, and are very similar to the older banks in the fens of this country. The golenas have a similar character to the forelands on our own rivers, such as those contained within the Bedford Level Banks; others are to be found of a similar character in Holland, and in all low countries. Fig. 2, plate XIII., is a specimen of the golenas and master-dykes.

High floods in the Po always go over the minor dykes protecting the golenas, of which it may be remarked that the soil is always dark; whereas,

that which is cultivated under protection of the master-dykes is of a light colour. We may remark here that this characteristic change of colour we have known to occur in this country in the case of lands newly embanked from the sea, within two seasons of cropping. The following is a table of the height of the lands above the water levels, on the 22nd September, 1813, the height at Pontelagoscuro having been then 1.3 feet above ordinary summer level.

	LEFT BANK.		RIGHT BANK.	
Height above River, in feet ...	Golena.	Plain.	Golena.	Plain.
Between Stienta and Pontelagoscuro ...	4.6	—	15.7	7.9
,, Pontelagoscuro and Francolino...	11.8	3.3	—	2.7
,, Polesella and Crespino	12.2	4.0	12.8	2.0
,, Santa Maria and Cavanella ...	9.4	2.4	8.7	5.6*
,, At the Gnocca Branch (Adriatic.)	—	—	4.3	0.8

*This part was raised by breach open between 1705 and 1728.

This table shews the marked difference of level between the golenas and the embanked country; a difference which is caused by the warping up of these lands within the minor banks. But the levels shew it to be a vulgar error to suppose that the Po is raised above the adjoining country. Further in the year 1847, Lombardini writes, that on the left bank of the Po, between Cremona and Casalmaggiore, the neighbouring country is from 11.5 feet to 15 feet above summer level, and at 2½ to 3¼ miles, it is from 10 to 13 feet; thence, to the Oglio, it is from 15 to 16.4 feet near the river, and at a distance 11.5 to 13 feet. From the Oglio to the Mincio, the lands at a distance from the river are 10 to 13 feet, and near the river from 13 to 16.4 feet above summer level; from the Mincio to the Fosse d'Ostiglia, they are from 13 to 19.8 feet; and finally, at the low parts of the marshes of Verona, the plains are from 5 feet to 6.6 feet above summer level; and again, further down where the Polesella Canal diverges from the Bianco Canal, the lands are from 8 to 13 feet above summer level. On the right bank the facts are similar, the ancient marshes of Boleno, now under cultivation, being from 5 to 11 feet above summer level of the river.

The spring and surface waters of the high plain, which would accumulate and drown the low lands during flood time, are carried from the high lands to the main river, either by canals in the form of catch drains in the central district; or in the lower district by embanked canals, which pass the waters through the low plain, up to the river at its main dykes. These secondary embankments are of service by limiting the extent of flooded land in case of a breach; they formed part of the original design, but have been much improved from time to time. Among numerous other instances may be quoted the Delmona canal, which was made about A.D. 1300 (the date of the great dyke below Cremona) for taking off upland water between Cremona and the Oglio. This work appears to have been unsufficient, for about A.D. 1550 the Robecco canal was made to carry water from Villanuova, down towards the Oglio in one direction, and towards Cremona in the opposite one.

The general effect of high floods on this river, and the manner in which they are reduced by breaches in the master-dykes, is shewn in the following page; wherein is also shewn the volume and duration of some of the more important floods.

TABLE OF HEIGHTS OF MAXIMUM FLOODS OF THE PO DURING THE NINETEENTH CENTURY,

As registered at various points on the river above summer low water, which at Piacenza is 132.3 feet above the sea level; at Cremona, 104.2 feet; at Isola Pescaroli, 89.2 feet; at Casalmaggiore, 74.8 feet.

Name of Station.	Dist. from the Sea.	1801 13th Nv.	1807 12th Dec	1812 15th Oct.	1823 16th Oct.	1827 13th My.	1839 20th Oct.	1839 8th Nv.	1840 6th Nv.	1841 31st Oct.	1846 20th My.	1846 20th Oct.	1855 1st Nv.	1857 Oct.
	Mls.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.
Monticelli	210.0	23.0	...	21.9	...	...	23.9	17.8	23.0	21.8	25.6	26.9	25.5	28.7
Piacenza	196.3	24.9	...	...	...	...	26.4	23.1	24.4	24.6	26.2	27.3	26.2	28.0
Cremona	171.9	19.6	...	...	16.1	17.2	18.7	18.3	18.7	18.4	18.3	18.8	19.2	20.8
Isola Pescaroli	155.9	20.6	...	19.8	17.7	18.6	19.6	19.2	18.5	18.9	20.0	19.4	20.2	21.6
Casalmaggiore	141.8	21.3	...	19.1	18.1	20.6	21.1	21.1	20 0	21.2	21.2	21.8	21.1	22.5
Dosolo	125.4	26.9	25.7	...	24.6	...	25.4	26.2	25.5	26.1	25.6	26.1	26.8	...
Borgoforte	114.5	27.6	27.0	27.0	25.6	26.9	26.5	28.1	25.5	25.8	26.7	27.1	28.2	29.3
St. Benedetto	100.5	25.9	26.2	27.9	27.8	28.2	27.5	29.2	26.9	27.5	27.5	28.2	28.6	29.3
Ostiglia	88.4	28.4	29.2	30.1	29.9	29.7	29.8	31.3	28.8	29.7	29.9	30.3	30.7	31.7
Sermide	76.9	26.5	27.0	28.1	28.2	27.7	27.7	28.5	26.4	27.4	...	28.1	28.2	...
Quatrelle (Stellata)	66.5	26.4	27.4	28.6	28.4	28.1	28.0	29.0	27.2	27.6	28.1	28.5	28.2	29.7
Ponte Lagoscuro	53.9	25.2	26.0	26.8	26.6	26.8	27.3	28.1	27.1	26.5	26.6	26.8	26.9	28.1
Polesella	43.9	...	...	25.8	25.8	26.0	26.6	27.7	26.3	26.1	...	...	...	27.9
Crespino	36.1	...	...	24.2	24.2	24.6	24.6	25.5	25.0	24.5	...	...	...	25.6
Cavanelladi Po	19.1	...	...	17.9	18.0	18.4	18.8	19.6	18.6	18.5	...	...	...	...
Porto Scanarello	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.31

At Pontelagoscuro the Highest Floods of the Eighteenth Century were A.D. 1705, Nov. 8th, 22.4 feet; 1719, Nov. 4th, 22.4 feet; 1729, Nov. 9th, 23.4 feet; 1733, May 6th, 23.9 feet; 1755, Oct. 23rd, 24.4 feet; 1772, Sept. 22nd, 25.0 feet; 1777, June 18th, 25.5 feet; 1799, July 14th, 25.6 feet; these indicate the same gradual rise that is evinced in the present century up to 1839. It was in 1705, that the great destruction of the master-dykes occurred; after this year they have constantly been less breached, until 1839, since which date no breaches have occurred in the great valley of the Po, below Cremona, with the exception of two small ones, which occurred in 1857 on the right bank near the Parma torrent. The floods of 1801 and 1807 created great breaches between Dossolo and St. Benedetto; in comparing their heights with that of 1839, it will be seen, that without these ruptures the flood would have been 3.34 feet and 2.36 feet higher than they were at St. Benedetto.

DISCHARGE AND DURATION OF MAXIMUM FLOOD AT PONTELAGOSCURO, NEAR FERRARA.

Drainage Area 26,754 square miles.

Date of Flood.	Duration of Flood.	Maximum above Warning Signl.	Discharge per Minute.			Depth run off District.	
			Maximum	Mean	Mean per Sq. Mile.	Total	Mean per day.
	Days.	Feet.	C. feet.	C. feet.	C. feet.	Inches	Inches
1827, 12 May to 1 June	20	8.34	10,694,600	9,599,050	358.79	4.45	.222
1827, 30 Sept. to 5 Oct.	5½	5.41	9,942,330	9,143,470	341.76	1.11	.212
1829, 17 Sept. to 9 Oct.	22	6.53	10,281,370	9,192,205	343.58	4.69	.213
1833, 30 Sept. to 6 Oct.	6½	5.51	9,976,230	9,285,440	347.07	1.34	.215
1835, 4 Sept. to 10 Oct.	6	5.74	9,993,200	9,171,015	342.79	1.28	.213
1836, 11 Sept. to 20 Oct.	9½	6.29	10,205,085	9,236,700	345.24	1.95	.214
1839, 9 Oct. to 25 Dec.	77	9.72	10,910,700	9,501,580	355.14	16.96	.220
1840, 2 Nov. to 18 Nov	16½	8.67	10.758,150	9,662,622	361.16	3.64	.224

EXTRAORDINARY FLOOD OF OCT. 20th, 1857, AND OTHERS AFFECTING THE PO.

The flood of October, 1857, surpassed any previously known flood and caused immense damage to the embanked plains, on the 23rd of October. It carried away both road and railway bridges on the Dora Baltea and other tributaries; and all communications were stopped in the various mountain passes. The storm commenced on the 18th and 19th by a violent hurricane from the south with deluging rains that extended over the Mediterranean and Adriatic, stretching from Naples to Dalmatia: it reached the valley of the Po, during the night of the 21st, with an east wind, varying from south-east to north-east, accompanied by warm temperature rising from 57° to 63½° Fahr: this combined an enormous melting of the snow, in the Maritime and High Alps, with the rain. At Becca, the mouth of the Ticino, the water rose, in 48 hours (from the evening of the 20th to the 22nd) to 7.5 feet above ordinary floods, and about 3 inches more before midnight, attaining at its maximum 2.75 feet above the highest flood of October, 1846, or 23 feet above ordinary summer level. The following table gives the particulars of this flood.

	Date of Max. Flood.	Height above Ordinary Summer Level.	Height above Lowest Water.	Distance of Stations apart.	Time in which Crests of Flood passed down.	Velocity per Minute of Crest of Flood.	REMARKS.
	Oct.	feet.	feet.	feet.	hours.	feet.	Velocity retarded at Cremona by the bursting of the banks above, by which a vast area of country was deluged.
Becca	22 midnt.	23.0	....	...	...	...	
Piacenza..	23 3 p.m.	24.0	28.0	196,850	15	218.6	
Cremona..	24 6 a.m.	17.7	20.8	122,170	15	135.7	
Borgoforte	25 11 a.m.	26.1	29.3	298,480	29	171.5	
Ostiglia ...	25 11 p.m.	26.7	31.7	137,890	12	191.5	
		Becca to Ostiglia		755,390	71	177.3	

The addition of other affluents and regularity of channel made the velocity of the crest below Ostiglia more constant. The only recorded floods that at all approached this of 1857, were those of 1705, 1801, Nov. 8th, 1839, and 1846. The floods of 1839 and 1857 attained exactly the same height at Pontelagoscuro. See table, preceding page.

The great flood of 1839 attained its maximum between the 12th and 15th of November, when it burst the dykes below Revere to the extent of 2,500 feet; the maximum which passed down in any one entire day was as above, 10,910,700 cubic feet, or 407.8 cubic feet per minute per square mile, which is equal to a depth of .253 of an inch, run off in 24 hours. But, when the dykes were broken through, the waters had to fill out over lands which were 19.5 feet below this high flood; this must have taken about 11,000,000 of cubic feet per minute, during two days in which it was swelling out over the marshes.

Lombardini appears to consider that the maximum flow at this period attained 13,000,000 of cubic feet; so that the total, including the quantity spread over the low lands, would have amounted to 24,000,000 of cubic feet per minute; according to this, the quantity actually flowing by the main river and its affluents was equal to about 900 cubic feet per minute per square mile, which is .588 of an inch in 24 hours.

It may be noted, as a proof of the difficulty of retaining rivers of this class within embankments on such extraordinary occasions, that the breaches above quoted were again followed by vast breaches lower down the river, on the 17th of November. These data and the other tables, evidence the well-known fact that heavy floods of this kind carry a head

with them, or maximum point continually moving forward at a somewhat uniform rate.

Owing to their southerly position in first receiving rains, and their shorter course, the floods of the Apennine torrents generally precede those of the Po, whose Alpine tributaries are decidedly controlled by the great lakes. In the upper part of the Po, floods last three or four days, in the lower part fifteen to twenty days; but that of 1839 was above the warning signal for seventy-seven days continuously. This approaches the character of a Nilotic flood; for 16.96 inches flowed off the entire area drained in the 77 days.

We have no proper reference to the rainfall registered on the Alpine slopes during these great floods; but on reference to the rain tables, some light will be thrown on the general diffusion of heavy fall along the South of Europe at all these periods. The rain at Florence in September, October and November, 1839, gave 4, 5 and 8 inches respectively; while the 16.93 inches were running off the Po basin, the fall at Florence was 16 inches; at Rome the fall in 1839 was a maximum, and in September 15.4 inches fell, being about three times the usual quantity. In November, 1840, the fall at Florence was about 6 inches, but the two previous months had about 9 inches; the aggregate was much above the average. In October, 1846, the rainfall at Florence gave 9.5 inches; at Trieste and Milan the fall in this month was about 12 inches; at Bordeaux 6.9 inches, and at Rome 8.8 inches, all of which are more or less maximum quantities.

Referring to the Table of Heights of the River Po at Casalmaggiore between 1827 and 1836, it will be seen that the rise corresponding to high flood is 16.1 feet to 17.6 feet, which would give about 11,500,000 cubic feet per minute; moderate floods rise 7.4 feet to 9.0 feet, giving about 4,250,000 feet; and the general result shews that the River Po is in a state of flood of about 5,000,000 cubic feet for 37 days in the year, when it carries about 300th part of its volume in the shape of sediment.

Lombardini considers that there is no increase in the actual discharge of the Po, in heavy floods, below the Ticino, owing to the vast quantity stored up by the rising of the waters over the valley. He says that the high flood of October, 1846, had a velocity in the main channel, at Becca (the mouth of the Ticino), of 393 feet per minute, with a discharge of 13,250,000 cubic feet; but that the flood had widened out to 4,000 feet in width, with a mean velocity of about 60 feet per minute. The mean of these velocities is not unlike that at which the head of the flood passes down the valley of the Po. It is evident that a width of 4,000 feet, with a rise of more than 20 feet, must absorb a vast quantity of water in the mere filling. It would take a week to fill such a width and depth in the length of the river between Becca and its sea mouth, at the rate of about 9,000,000 of cubic feet per minute. Taking, therefore, the observed maximum discharge at Pontelagoscuro at 11,000,000, we have probably about 20,000,000 of cubic feet per minute, as the maximum quantity due to the tributaries of the Po at this place, not actually flowing down (although flowing off the drainage area), owing to the impossibility of its passing off. The area being 26,754 square miles, the discharge would be equal to 822 cubic feet per minute per square mile, or .51 of an inch in depth run off per diem.

THE FLOODS OF THE ALPINE TRIBUTARIES.

In a flood lasting from the 8th to 23rd September, 1829, a period of fifteen days, the Lake of Como rose from 5.36 feet to 12.73 feet. During this time the flow into the lake increased from 1,191,500 cubic feet per

minute to a maximum, extending over twenty-four hours, of 4,086,500 cubic feet per minute. On the 23rd this was reduced to 1,462,300 cubic feet per minute; the mean flow over the whole period being 1,776,460 cubic feet per minute. The mean flow out of the lake was 1,194,180 cubic feet per minute during the same time; the amount stored in the lake at the end of the fifteen days being 12,600,000,000 cubic feet, which is equal to 582,000 cubic feet per minute during that period.

The area of the water surface of the lake increased from 56.72 square miles on the 9th to 63.75 square miles on the 23rd of September.

The drainage area of the district, including the lake, is 1,728 square miles. The mean total flow into the lake was 1,037 cubic feet per minute per square mile, giving a total depth of rain run off or stored in fifteen days of 9.63 inches, or .64 of an inch per diem for fifteen days consecutively.

By the flood of the 21st to 22nd of October, 1857, Lago Maggiore was raised 4.26 feet in twenty-four hours. The quantity flowing out, combined with the accumulation in the lake, during these two days, was 2,950 cubic feet per minute per square mile, giving a total flow of 3.66 inches off the surface during the two days; of which only one-seventh part was able to flow out of the lake during the period. This appears almost without precedent, and is evidently due to the melting of snows not less than to actual rain.

The above flood in Lago Maggiore was exceeded by a flood of October 17-18, 1846, when the rise was 5.25 feet in twenty-four hours, caused by an excessive rain, accompanied by a sudden warm wind and rise of temperature from Fahr. 42° to 63.5°, which caused great melting of snows in the Alps; owing to the direction of the wind, this flood was chiefly on the Toce branch of the Ticino; the main river not being much swollen.

The storm of October, 1857, appears to have broken over the Alps in a partial manner, although, as will be seen by the following statement of the quantity gauged in the Italian Lakes during the flood, a flood at the Lake of Geneva, which occurred in 1840, is given for comparison.

	Date of Flood.	Height at Commencement.	Gauge at Max.	Area of Lake.	Drainage Area.	Total.	Quantity Impounded Per sq. mile	Estimated discharge Per sq. mile.	Total run off Per sq. mile.	Depth run off per diem.
1857.	October.	feet.	feet.	Sq. mls.	Sq. miles.	Sq. miles.	C. ft. per M.	C. ft. per M.	C. ft. per M.	inches.
Lago Maggiore	21st to 22nd	7.88	12.15	77	2,418	2,495	2,550	400	2,950	1.83
Lake of Como..	21st „ 24th	2.75	4.73	58	1,670	1,728	450	250	700	.43
Lake Garda.....	20th „ 24th	2.33	2.43	144	788	932	75	100	175	.11
1840.	September									
Lake of Geneva	17th „ 18th	5.10	6.00	208	2,792	3,000	1,120	530	1,650	1.02

The flood of 1857 was rather below that of 1846 on Lago Maggiore; but on Lakes of Como, Iseo and Garda it was not by any means a maximum flood. A flood of June, 1855, appears to have reached about three times the above volume, or say 2,100 cubic feet per square mile on the Lake Como; probably a similar amount is discharged in extreme floods from the Lake Garda. This table gives a proof of the concentration of great rain storms, inasmuch as it shews that the most violent storm of 1857 was partial in its most violent effects over the district, although the flood of the Po was the highest on record.

It is remarkable that although the storm of October, 1857, did not pass over to the north side of the Alps, yet the south and east slopes of the Cevennes Mountains had deluging rains on the 10th and 25th of September and 5th of October, 1857, which caused immense damage in the

Ardèche. There was an extreme gale on the 7th and 8th of October, 1857, in the English Channel, on the coast of Dorsetshire.

The example at Geneva, September 17th, 1840, was an occasion when the fall of rain in 24 hours was 2.83 inches at that place; an allowance is made for this in calculating the amount of flow off the area due to the rise of the lake in the 24 hours.

In the great flood of May 28 to June 1st, 1856, which so deluged the whole of the south of France, the Lake of Geneva rose altogether about 11.6 inches between the 27th and 30th, during 66 hours of which time it rose 8.7 inches. This rise represented 1,375 cubic feet per minute per square mile, of which 618 cubic feet was flowing out of the lake; this would be at the rate of 2.5 inches in the 66 hours, or .9 inch per diem off the surface. The rain that fell at Geneva from 10 p.m. of the 28th to 8 a.m. of the 30th May, was 4.06 inches; so that the flow off in 2.75 days was as 2.5 to 4.06 = .61 of the observed rain fall at that place.

The centre of this great rain storm of May—June, 1856, broke over the country stretching from the head of the Loire to the head of the Rhone. The vapour which caused it was evidently driven up from the Atlantic; not from the Mediterranean, otherwise, the southern slopes of the Alps would have felt the storm. It is highly probable that the rain sources of France and Italy have this general distinction.

We have given the diagram, fig. 4, on plate XIV. from various data and partly from Baumgarten (*Ponts et Chausées*, 1847,) to shew the mean volume of the Rivers Po, Seine, Soane, Adda, and Tiber, with the rainfall and mean temperature for similar periods. The curves are highly suggestive, and indicate the great reduction which takes place, when snows cease to melt, and high summer temperature reigns; and in the case of the Po, when irrigations absorb vast quantities of the perennial flow; in strictly glacial rivers, however, the minimum flow is in severe frost.

AS TO THE PERMANENCY OF THE BED OF THE PO.

There is no doubt whatever that the average bed of the river above Ostiglia has remained constant for many centuries, notwithstanding that the bottom presents undoubtedly an extreme variable character, according to the local circumstances. It is below Ostiglia that the delta commences, and the surface gradually approaches the sea level; the entire plain being of a much lower character than in the upper district. (*See ante.*) Lombardini considers that in no part of the Ferrarese plains has the bed of the Po materially altered, and certainly not more than about 5 feet in any point, since 1705; but that the floods undoubtedly rise higher than formerly. This is explained by the fact that the barrier banks have been continually strengthened, so that the lowering of the waters, by their bursting, does not now occur. Thus, it appears that since 1839 there have been no breaches of the banks, and that simultaneously the floods have not risen, except, as in 1857, by the magnitude of the floods; as will be seen by the Table of Heights of Floods.

The original embankment of a river undoubtedly always raises the level of floods, and augments the *maximum flood* discharge, because the reservoir formed by the embanked lands is unavailable for the reception of flood waters; but this amount of rise is limited, for the increased sectional area, formed by the body of water confined in one great canal, rapidly accelerates the power of discharge.

Now it appears that since 1604 the river has extended its mouth 72,000 feet seaward, and the fall from a point the same distance from the present mouth as Ferrara was from the sea in 1604 (35 miles) is 7.54 feet, while

the present difference of surface level between Ferrara and the sea is about 15.54; so that it is possible for the rise at Ferrara to have been between 7 and 8 feet since that date This would give a fall of 7½ inches per mile for the extension of the delta, but the windings would reduce it to about 5 inches; but as the surface fall of the river is very small, it is probable that the actual raising at the parallel of Ferrara does not exceed half that quantity.* In floods, however, we have another state of things, and it is doubtful whether their velocity would permit much filling up of the bed; the inference is, that there may be greater sectional area to provide for the reduced fall caused by extension of the delta. This is confirmed by the fact that the river is of very great depth in this part of its course; indeed, the material of deltas of this class of rivers is generally of a lighter and more mobile character than the upper courses, and the greater sectional area is a natural sequence.

Lombardini thinks that the curve of surface, formed by high flood waters, commences to bend towards the sea level at Pontelagoscuro, opposite Ferrara. See plate XIII., section of the Po in flood and ordinary waters.

His conclusions are these:—

"That where the Po is embanked, its level is never above the neighbouring country."

"That opposite Ferrara the surface of high floods is higher than formerly; but that this is owing to the perfect state of the dykes, and the extension of the sea mouth since 1604 about 13 miles beyond the then distance of 35 miles."

"That lengthening the bed of the Po acts in two ways on the height of floods—first, in raising to a small extent the height of ordinary waters in the lower section of the river; and then in bringing nearer to the sea the points where the profiles of flood and ordinary waters begin to converge."

None of these data require, as a condition, that the bed of the river should have risen; and indeed such a fact as the raising of the bed by sands and gravels collected between the dykes would be contrary to the natural laws which regulate the flow of rivers with mobile beds.

The Adige, however, say the opponents of the above theory, is an example to the contrary; for a portion is in fact higher than the adjacent country, as will be seen by the section, plate XIV. This occurs with many kinds of torrential rivers at the point where they flow out of mountains into the low lands bordering the Adriatic. The sections of the Reno and Adige will shew this clearly. It may be remarked that the Adige changed its course, A.D. 589, from one much more northerly, and took a new channel among what were then low and marshy lands.

Paleocapa, the engineer-in-chief at Venice, states that the bed of the Brenta is, at one part, above the surrounding country; but he also corroborates the general statements and arguments of Lombardini relative to the height of the Po.

The Reno is quoted by Lombardini as a test of the effects of embankments. Its course was much altered in 1771, being cut off from its ancient connection with the Po below Ferrara, and embanked in a new channel, which had anciently formed a southern branch and sea mouth of that river.

* The ancient course of the Po was through the channel termed the Po de Volano, on the edge of which Ferrara is built. A section across the space intervening between the bank of this channel and the main river at Pontelagoscuro shews that the site of the town is 9 feet *above* the present lowest summer water, and the ancient river bed is 2 feet *above* the same level; but this may have been raised artificially in the great length of time which has occurred since this course was abandoned.

Lombardini thinks that between 1761 (when the new dykes were commenced) and the present time, the bed of the Reno has risen less than 4 feet; but even this had occurred in 1801, since which the bed has varied from time to time, sometimes being deeper, and again having filled up, probably according to the seasons, and the violence of floods and varying amount of sands brought down from the mountains. It is thought by the best authorities that the bed of the Reno has long since acquired a character of permanency.

There is one remark of Lombardini well worth recording on this matter, viz., that there is too much embanking near the mouth of the Po; for the matters carried by the floods are thus cast into the sea, which would otherwise have been deposited upon the low lands; the embankment having the double inconvenience of preventing the raising of the lands, and of extending the river mouth seaward. It is hardly necessary to add, that this remark would apply well to a river such as the Po, carrying an enormous amount of alluvium, while to a smaller and less mountainous river, or one derived from more primitive rocks, no such effect would occur.

AS TO THE DELTA OF THE PO.

We have treated of the Reno and the Adige as part of the River Po, because it is clear that they have all been for greater or less periods joined, and the delta is in fact one joint operation of the major and minor rivers; but inasmuch as they are of far more torrential character, and their mouths are nearer to their mountain sources than those of the Po, it is probable that they have proportionally a greater influence on the sea banks, or outlying projections of the delta.

The southerly are the ruling winds of the Adriatic, but those from the east are most violent. Their combined effect is to raise up the usual banks and bars from the materials brought down by the rivers of Lombardy; and these are continually augmenting by blown sands, forming dunes. The ruling drift of the coast is southwards, *i. e.* towards Ravenna, according to Capt. Spratt; and the increase of growth of the delta appears to be greatest in that direction.

These dunes have been frequently formed on banks at a considerable distance from the shore, forming lagunes within them. Such are those of Venice and Comacchio; and such also existed formerly, at the back of which the ancient town of Adria was built, thence called the city of the seven seas. Traces of these ancient dunes may be still seen, stretching from Brandolo to Mesola, and dividing into three branches at the crossing of the Po. (*See plate XIII. for these dunes and ancient sea-margin of the Delta.*)

Ravenna, which stood on the sea about 200 B.C., is an excellent measure of advance; for it is now upwards of 4 miles from the sea. This gives a progress of about 10 feet per annum. Adria is situate more at the maximum point of growth; 2,000 years since, it was a port of the Adriatic, and at present it is upwards of 20 miles from the coast. This would give to the delta an advance seaward of 52 feet per annum.

Prony calculated that, between A.D. 1200 and A.D. 1600, the Po advanced at the rate of 82 feet per annum, and formed land at the rate of 175 acres yearly. Between A.D. 1600 and A.D. 1800, it is considered to have extended seawards, 229 feet, and in area, 280 acres per annum. That of the Rhone, since 1712, has not been more than 57 acres per annum. This is suggested to be by the superior depth of the mouth of the Rhone, which, at the distance of six miles from the beach, is (100 mètres) 330 feet in depth; and the tide has a transverse velocity of 100 to 200 feet

per minute: whereas the depth of the Adriatic, at the same distance from the shore, is not more than 100 feet deep, and the transverse velocity not one tenth of the former case. It may be doubted, however, whether this is not the effect of superior amount of deposit in the case of the Po and the two rapid torrents of the Adige and Reno descending into the same delta; their mud may have jointly shoaled to a much greater extent, the adjacent sea bed during past ages. In reference to the amounts run off the respective areas, it is also evident that the disintegration of the Po basin is greater than that of the Rhone, from the larger amount of rainfall evidenced by the larger mean flow. (See Table of Rivers.) The Italian slopes of the Alps are of a more recent and tertiary character than the Northern slopes, and those of the Jura and Cevennes mountains, drained by the Rhone and its tributaries: this cause, acting for an immense period of time, has produced the marked difference in the extent and character of the deltas of rivers, which otherwise are similar: that is, the drainage area of the Po and minor branches, including the Adige and Reno, all of which have contributed to the great delta extending from Venice to Ravenna, is one third less than that of the Rhone, whilst the delta is larger, being about 2,800 square miles; that of the Rhone being only 2,500 square miles. The question is, however, highly speculative, as we have no means of judging what were the relative depths of the gap to be filled up when the formation of the delta first commenced: a period probably coeval with that at which the river lines were created by the upheaval of the Alps. (*See notice of the Nile on this subject.*)

The following tables give particulars of the mean heights of the River Po, in ordinary and flood waters, with the observed levels and surface slopes, and other information relative to the height of marsh lands below floods. Similar matter is also added of the Reno, the Adige, and the Rhone, which afford means of comparing the characters of these kindred rivers. The information is chiefly taken from Elia Lombardini, the eminent engineer-in-chief of the river Po, and from papers in the *Ponts et Chausées*, by several experienced engineers, who derive their matter chiefly from this great authority. From these authorities we have given the table of the heights of the more important floods for the past and present centuries, and the discharge and duration of the greatest floods. The portion of these notes on the Po, which consists of an analysis of some heavy floods of its affluents, is given to shew the enormous character of some Alpine floods; their effect on the great Italian lakes is to render them compensating reservoirs, to some extent controlling the diluvial rains and melting of snows, which periodically threaten the safety of everything on these rivers.

We have omitted to describe the system of irrigation from the Alpine and Apennine rivers, being foreign to the special objects of this treatise. (See Baird Smith.) Along the whole southern slopes of the Alps, and on many of the northern ones in the south of France, the rivers are dammed up, and taken off at suitable points by numerous canals, whence smaller ones diverge, which irrigate the major portion of the plains of Tyrol, Lombardy, and Piedmont. The points of derivation are generally where the rivers debouch from the mountains. In the Tables at page 156 is given an account of the volume used for irrigation over the plains of Lombardy, defining the rivers taken in this district. This does not include a large quantity abstracted from the mountain streams in Piedmont and on the Apennine slopes. *

* On the river Dora, about 12 miles from Turin, at a point where it leaves the mountains, there are five bealareas taken off within a short distance; in hot weather, their water disappears before it has passed over the twelve miles of irrigated lands situated on the north of the river Po.

THE RIVER PO.

MEAN HEIGHT BY TEN YEARS' GAUGINGS AT CASALMAGGIORE. 1827 to 1836.

NOTE.—Ordinary summer level is the zero of the gauge; the greatest drought of 1817 having been 1.62 feet below this zero, and the greatest flood of 1801, 18.25 feet above this zero. Medium floods standing 8 feet, and ordinary floods 11.1 feet thereon; top of the Dykes being 15 feet on the gauge.

Month.	Hgt. of Water above zero.			Duration of predominant state of the River.						Observations.
	Min.	Max.	Mean.	From	To	Days.	From	To	Days.	
	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	
January	1.3	10.2	1.6	0.8	0.8	13	0.8	2.5	19	Minimum state from frost
February	1.3	11.2	2.0	0.8	0.8	9	0.8	2.5	17	
March	0.3	15.0	3.5	0.5	2.8	9	0.2	3.5	15	
April	1.6	13.8	3.4	2.8	4.4	6	2.8	6.1	10	
May	0.3	17.6	6.6	5.7	7.4	8	5.7	9.0	12	Maximum state from
June	0.7	16.1	6.5	4.8	6.4	9	4.8	8.1	16	melting of snow in the
July	1.0	11.2	4.1	2.2	3.8	15	2.1	5.4	23	Alps, about 11,547,440 cu-
August	0.0	12.5	3.0	1.1	2.8	11	0.5	3.8	20	bic feet per minute.
September	0.7	15.5	5.6	3.1	4.8	9	2.5	5.8	15	Mean flow about 4,247,560
October	0.3	15.8	6.2	1.5	3.1	6	1.5	4.8	9	cubic feet per minute.
November	0.3	11.2	3.5	1.1	2.8	11	0.5	3.8	19	
December	1.0	12.8	2.0	0.2	1.8	15	0.2	3.5	23	Low from frost.

LEVELS OF THE RIVER, AND SURFACE SLOPE.

Drought of September 22nd. 1813, and Flood of October 15th, 1812.

Place.	Distnce. apart.	In Drought.		In Flood.		Remarks.
		Height ab. Sea.	Fall per mile.	Height ab. Sea.	Fall per mile.	
	miles.	feet.	inches.	feet.	inches.	
Stellata	...	22.7	...	...	...	The irregularity of the falls between Ponte Lagoscuro and Cologna is probably caused by severe bends in the river. The surface fall of the river in droughts between Cologna and the sea is about two inches per mile.
Palantone	3.1	...	...	39.6	...	
Ponte Lagoscuro	9.0	16.2	6.4	36.6	7.0	
Zocca	7.5	11.8	7.0	33.8	4.5	
Polesella	2.3	11.1	3.7	...	...	
Guarda Ferrarese	2.2	...	...	28.6	13.9	
Cologna	5.4	8.4	4.2	25.6	6.6	
Berra	4.1	7.0	4.2	22.6	8.7	
Santa Maria	4.7	5.9	1.6	...	...	
Taglio di Po	10.6	3.2	3.0	...	...	
Pier of Farsetti	6.8	2.4	1.6	...	...	
Muestra Mouth	8.3	1.0	1.9	0.0	8.9	

LEVELS OF MARSH LANDS IN RELATION TO FLOODS.

Place of Observation.	Level of Lowlands below.		Place of Observation.	Level of Lowlands below.	
	Extraord. Floods.	Ordinary Floods.		Extraord. Floods.	Ordinary Floods.
	feet.	feet.		feet.	feet.
From Cremona to Pescaroli (Left Bank)	5.9 to 10.5	7.0 to 3.9	Near Portiolo (Right Bank)	13.8 to 14.8	4.3 to 5.2
From Pescaroli to Casalmaggiore	7.0 to 12.1	0.0 to 5.2	From the Mincio to Ostitia		
From Casalmaggiore to the mouth of the Ollio	9.8 to 11.8	1.6 to 3.6	At Troldo de Sacchetta (Left)	9.8 to 10.8	0.1 to 1.1
From the Ollio to the Mincio, viz.: at Ronco Corrente (Left)	13.1	3.8	At Guingentole (Right)	18.1	7.9
			Above Revere ,, ...	17.1	6.6
			Below ,, ,, ...	16.4	5.9
At Villa Gandelli (Left)	15.7	6.2	Below Lamide ,,	8.5 to 11.8	1.8 to 1.5
At Fenelone (Left)	11.8	2.3			
At Troldo Bulgarini	13.1	3.6	Above Stellata ,,	11.2 to 14.4	2.0 to 5.3
Near Governolo	15.4 to 17.4	5.7 to 7.7			

THE RIVER PO.

TABLE OF HEIGHTS AND SURFACE SLOPE IN DROUGHT AND FLOOD.

The Flood is that of November, 1839. The datum is mean level of the Adriatic at Port Maëstra. Spring Tide range = 2.85 feet. Neap Tide range = 1.77 feet.

Place of Observation.	Distance from the Sea.	Level of ordinary Summer Water.	Rise of Flood above ordinary Summer Water.	Surface Fall per mile.	
				In Drought.	In Flood.
	miles.	feet.	feet.	inches.	inches.
Source of the Po, at Monte Viso..	416.07	801.74	...	...	...
Villa Franca	387.30	559.60	...	101.00	...
Poncalieri.....	378.10	520.71	...	50.72	...
Moncalieri	359.69	462.38	...	38.07	...
Turin—Mouth of Dora Riparia...	355.08	450·47	...	33.60	...
Chivasso	336.67	405.78	...	29.77	...
Mouth of the Dora Baltea	328.10	385.47	...	28.20	...
,, Sesia	295.83	314.04	...	26.59	...
Valenza.....	283.74	288.32	...	25.55	...
Mouth of the Tanaro	274.04	270.34	...	23.45	...
,, Sommo	241.17	207.00	...	22.77	...
,, Ticino	228.51	183.53	...	22.20	...
,, Olona	216.88	166.37	...	17.71	...
,, Tidone	208.21	153.48	17.8	17.80	
,, Lambro	204.47	148.50	...	15.97	12.04
,, Trebbia	194.80	136.26	...	15.20	
Piacenza	192.82	132.28	23.1	24.00	
Mouth of the Adda	174.30	110.77	...	13.93	15.95
Cremona	168.09	104.21	18 3	12.67	
Isola Pescaroli	153.18	89.24	19.2	12.05	11.32
Casalmaggiore	137.96	74.77	21.1	11.40	9.90
Mouth of the Crostolo	124.91	62.96	26.2	10.85	6.17
,, Oglio	114.66	55.41	28.1	8.83	6.61
,, Mincio.....	96.83	43.66	29.2	7.91	7.16
,, Secchia	95.21	42.58	...	7.99	4.81
Ostiglia.....	86.63	...	31.3	...	
Quatrelle	64.76	23.26	29.0	7.61	9.06
Palantone	61.16	20.70	...	8.53	7.60
Pontelagoscuro (Ferrara)	52.15	16.17	28.1	6.02	
Zocca.....	44.59	11.77	...	6.98	6.58
Polesella	42.27	11.05	27.7	3.72	
Cologna.....	34.66	8.40	25.5	4.18	7.33
Berra.....	30.52	6.95	...	4.20	7.27
Santa Maria	25.78	5.93	...	2.58	
Cavanella di Po	17.47	...	19.6	...	
Taglio di Po.....	15.22	3.24	...	3.06	15.45
Pier of Farsetti	8.39	2.36	...	1.54	
Port of Maestra.....	0.00	0.98	0.0	1.97	

THE RIVER RHONE.

TABLE OF HEIGHTS AND SURFACE SLOPE IN DROUGHT AND FLOOD.

From Lyons to the Mediterranean.

(*Ann. des Ponts et Chaussées, 1st Series*, 1833.)

Mouth of the Saône at Lyons ..	206.16	526.35	17.4	...	
,, Galaure	159.29	409.39	...	29.57	
,, Isère	141.85	357.39	...	36.00	39.37
Douzère.....	...	183.93	...	...	
Mouth of the Lez	78.68	110.70	14.8	46.86	
Abve. Embkt. opp. Roquemaure	65.37	72.41	20.7	34.52	29.20
Wooden Bridge at Avignon	...	43.83	21.3		
Mouth of the Durance.....	...	34.58	23.3	25.90	26.34
"Roche d'Acier"	...	28.45	24.6		
Tarascon	38.33	14.04	19.7		
Arles	28.64	5.87	19.1	10.12	10.87
Port de Bouc—Low Water.....	0.00	0.00	3.3	2.45	9.08

THE RIVER ADIGE.

TABLE OF HEIGHTS AND SURFACE SLOPE IN DROUGHT AND FLOOD.

The datum is mean level of the Adriatic, at the mouth of the River.

From Section given in the "Annales des Ponts et Chaussées," 1861.

Place of Observation.	Distance from the Sea.	Level of ordinary Summer Water.	Rise of Floods above ordinary Summer Water.	Surface Fall per mile.	
				In Drought.	In Flood.
	miles.	feet.	feet.	inches.	inches.
Pietra, near the Tyrol Boundary	128.59	384.69	7.87	...	...
Chiusa .....Gauge	116.83	301.10	11.15	85.28	81.79
Pescantina.....Church	107.81	240.40	11.13	80.60	81.04
Verona .....Gauge	97.04	164.48	10.17	84.65	85.72
Commencement Right Embank.	84.91	104.66	10.53	59.05	58.67
Albaredo .....Gauge	74.04	70.47	12.72	37.76	35.32
Legnago .....Bridge	61.64	52.80	10.00	17.11	19.69
Castagnoro .....Sluice	54.58	44.39	12.62	14.26	9.88
Badia..... „	49.92	40.13	11.91	10.97	12.86
Barbuglio.....Gauge	43.17	31.73	13.42	12.36	12.23
Baora Padovera..... .... „	32.94	21.33	14.40	12.17	11.03
Arguillara ..... „	26.58	15.06	13.77	11.60	12.80
Cavarzere..... „	15.58	5.74	12.46	10.14	11.60
Torre Nova .....Sluice	8.35	2.83	7.97	4.82	12.36
Fossone	1.20	0.30*	3.30*	4.24*	7.33*
The Sea.....	0.00	0.00*	0.00*	3.00*	36.00*

NOTE.—The figures marked * are assumed, and are probably correct; the actual levels are not given in the published Section.

THE RIVER RENO.

TABLE OF HEIGHTS AND FALL OF BED OF RIVER AND OF FLOOD.

The datum is mean level of the Adriatic, as above.

Place of Observation.	Distance from the Sea.	Level of Bed of River.	Level of Floods.	Fall per mile.	
				Bed of River.	Flood Surface.
	miles.	feet.	feet.	inches.	inches.
Foot of Mountains	80.87	157.68	168.14	...	...
	78.52	129.37	145.59	147.70	117.65
Commencement Ancient Embnk.	77.95	126.74	136.81	50.89	169.92
	76.77	...	121.39	...	156.82
	73.23	80.84	106.10	116.69	51.83
Cento.....	59.31	54.46	75.13	22.74	26.69
Casa del Dosso	52.23	47.67	67.42	11.51	13.01
S. Prospero	47.57	...	62.17	...	13.52
Gallo	44.22	31.50	...	24.22	...
	37.07	...	49.21	...	14.81
Traghetto.....	34.68	19.82	48.72	14.69	2.46
	28.21	12.40	44.59	13.75	7.66
Bastia.....	23.36	5.08	40.16	18.11	10.96
	17.80	.69	36.09	9.47	8.78
S. Alberto.....	8.88	...	24.90	...	15.05
	7.70	-4.63	...	7.15	...
	6.90	...	24.05	2.67	5.15
Léonarda	2.42	-9.42	11.38	...	33.94
	0.81	-5.91	3.61	...	57.91
The Sea.....	0.00	-3.28	0.00	...	13.20

The level and fall of Bed of River are given, as the levels of Water Surface in drought cannot be obtained. The fall of Bed in the lower part of River is calculated at 2.67 inches per mile, between 17.80 miles and the Sea.

RIVER NILE.

INTRODUCTORY REMARKS.

(See Plate XV.)

Girard, who was with the French in Egypt during 1799 to 1802, gives a very precise account of this river in a paper given in the Memoirs of the French Academy. Mr. Horner has collected many facts upon the Nile and its deposits in two papers given to the Royal Society, 1855 and 1859; from these and Girard's paper, and from Messrs. Talabot and Stephenson's surveys, we are able to give the following remarks, for which also we have used, with great advantage, Captain Spratt's Surveys and Reports on the Delta of the Nile, and Submarine Coast of the Mediterranean. Owing to the discussion of the Suez Canal question, matter has been given by these authorities which is new; their very accurate researches have afforded much assistance in the calculations of this article, and also in the deductions as to the volume of the Nile, for which we may refer to the Table of Rivers.

The Basin of the Nile is distinctively tropical, and the curve of its rise and fall indicates periodic rains similar to those prevailing in the India Peninsula; these rains are probably of very great amount (like those of the Bombay Ghâts) over large areas. The heavy character of its flood is strongly marked by the quartzose sand, of which such immense quantities are brought down. This forms the universal basement bed of the 600 miles of valley below the cataracts; of the delta; and of the sea bed from Alexandria to Syria for a distance of 10 to 20 miles from shore in 20 to 40 fathoms of water, and finally cast up by the sea and blown into sand hills, forming a great portion of the desert between Pelusium and Suez. (*Vide* Spratt and Adm. Charts.) The mud of the Nile, in contradistinction to the sand, is probably retained upon the lands of Egypt in a far greater proportion than it is carried to sea, especially during the few thousand years in which Egypt has been cultivated. The entire length and breadth of the land is artificially warped, and the velocity of waters in irrigation cuts probably would carry but little sand; at the velocity of High Nile, this material would undoubtedly roll down the lower part and bottom of the main streams to the sea mouths. Capt. Spratt's dredgings shew Nile mud, with every proportion of sand, between 1 and 50 per cent., within a few miles of the shore; but beyond the littoral zone of mud, sand is more generally prevalent. The facts appear to indicate the deposit of sand in large proportion during the extreme flood, and deposit of mud, or sandy mud, in the more quiet periods; other extreme conditions of the flood, probably afford vast quantities of both, in every kind of proportion.

To prove that the river brings a large quantity of sand into the Mediterranean during flood, he made experiments during Low Nile at five to ten miles above the Rosetta and Damietta mouths, and remarks thus:—"By a dredge taken in seven fathoms near Damietta, the proportion of yellow quartzose and black iron sand to black slimy mud was 45 per cent; the sand in which, being of unequal size, explained the origin of the variety of sand which is generally found on the dunes and on the shallows off the coast; and where the action of wind or wave sifts and gathers them, according to their size and gravity. Four miles below Damietta, the dredge in 28 feet brought up black slimy mud, in which the proportion of sand to mud was only 10 per cent.; in the Rosetta branch, at about nine miles from the entrance, the bottom contained

about 20 per cent. of sand; and again, at five miles, it contained about 40 per cent. of silicious sand. The sand and mud in this entrance came up in separate lumps, so that one sifting would yield 20 per cent., and another 50 per cent. or more; shewing that the mud was probably only a superficial covering. Below this, at two miles from the entrance, in three fathoms, the bottom brought up contained only 15 per cent. of sand. It thus indicated the irregularity of the distribution at this its low water season. The river this year being unusually low and sluggish, it transports comparatively little to the sea; merely such light particles of matter as are easily held in suspension in moving water, which I found to be only 17 grains per gallon, with an average current of 88 feet per minute. So sluggish, indeed, was the Nile at this time, that if the sea was calm, hardly any discoloration or turbidity was shewn, except immediately off the mouths of the river, or on a narrow zone of two or three miles along the coast. The greatest strength of the current in the Damietta and Rosetta branches did not exceed 115 feet per minute at the surface; but at the sides of the river and bottom it was insensible. Thus at dead Low Nile, when I examined the water, I found that it transported comparatively little matter to the sea, being merely such as it holds in suspension—as mud, or fine silicious particles. Therefore the finding of any sand at this time within the mouth of the river, under so sluggish a current, is an indication of the large quantity of sand which the Nile must bring to the sea during its flooded condition. The surface water at Atfeh, in October, when the current was about 300 feet per minute, contained 67 grains of mud per gallon, which is just twelve times as much matter as the surface water at the embouchures contained at Low Nile in the month of May."

Bearing in mind the manner in which local peculiarities of climate are regulated and absorbed by the vast extent of channel—lakes and diverse branches of this great river, we may be sure that the rise and fall will evidence most distinctly the broad characters of the rainy season over this enormous basin. Without any direct knowledge of the mountainous region at the sources of the Nile, we must turn to analogy. In applying the known volume and periods of the Nile flood to the observed meteorology of India, and especially of its Peninsula, which is similar in its vast mountains and its latitude to that of Abyssinia, it is sufficiently evident that the Nile is fed by rains, commencing in May and terminating with October or November, after which the subsiding flood is the natural result of the springs and draining off of the copious supplies of the rainy months. The distance to be traversed from the rainy country to the cataracts is probably on an average 1,000 miles on each branch of the Nile; requiring at least 20 to 30 days for appearance of the young flood at the latter place. To shew this analogy, we have placed on the plate XV. a diagram which shews the height and period of the rains of an average of 10 places in the mountainous parts of the Indian Presidencies, the details of which will be seen in the tables of rainfall for Bombay, Madras, Patna, Himalaya, Poona, Comorin, Cochin, Quilon, Vaurioor, Shenkottah, Moulmein, &c.

The floods are felt to rise below the first cataract about the 21st of June, and become sensible at Cairo in the beginning of July. This would make the travelling rate of the swelling river about 2 to 2½ miles per hour, but the bends in the river would probably reduce this speed to one mile and a half per hour. The observations of the height of the river from July, 1799, to March, 1801, shewn on fig. 1, plate XV., were kept by the French at the Nilometers at the extremity of the Island of Rhoda, near Cairo; the year 1846 is also given from Mr. Horner's treatise. (*Royal Trans.*, 1859.) During the first six or eight days the

Nile rises very gradually, after which its daily rise becomes more rapid; about the 15th of August it has almost arrived at half of its greatest height, which it attains ordinarily on the 20th to the 30th of September. When the maximum is reached, the river continues so for about 15 days, after which it commences to fall much more slowly than it had risen. On the 10th of November the Nile has descended to half the height, and its fall is continued until it arrives at its low state about the 20th of May in the following year. After this the river ceases to vary, excepting that it falls off gradually, owing to the intense heat, until the new flood again makes its appearance.

When the Nile enters Egypt in flood time, it is charged with sand and mud which give its waters a reddish colour; the river remains thus charged during the whole period of its *overflow*, and only gradually loses colour after it has returned within its channel, when it finally becomes perfectly clear. The bearing of this in fertilising the valley of Egypt will be seen on reference to the section, fig. 5, plate XV., which has the minor canals of irrigation and banks for retaining water distinctly marked thereon.

There is a period, after the flood has become red and turbid, when the waters assume a greenish hue. It would appear probable that this is from melted snows, for at this time the water is considered unwholesome; and from time immemorial the Egyptians have stored water for use until the unwholesome period has passed away.

The diagram, plate XV., has a year's curve of heights of the Nile, taken at Khartoum, where the Blue and White Niles join; this point is about 1,600 miles above Cairo, but by the bends of the river is much farther; it is about 1,280 feet above the sea. The juxta position of the two curves enables one to form a tolerable idea of the manner in which the flood moves forward; the interval is about a month, and the pace appears to be about 66 miles per diem, or 240 feet per minute, if the distance be 2,000 miles; this velocity indicates that the distance may be between these estimates.

DISCHARGE, VELOCITY, SURFACE FALL, AND HEIGHT OF INUNDATIONS OF THE NILE.

Linant Bey considers that at Cairo Low Nile gives 877,000 cubic feet per minute, and at High Nile 22,000,000 cubic feet. This latter cannot be the whole as so much is passed off by the great canals and other direct deviations on its 600 miles of course; for the derivation of the Magrour (afterwards called the Canal of Joseph) is 326 miles above Cairo, and its course is generally from 6 to 13 miles distant with innumerable smaller cross canals connecting it at High Nile with the main river. Girard gives a section of the Nile at Manfalout (20 miles below Siout), shewn in fig. 3, which on March 27th, 1799, had 12,150 s. feet of section with a velocity of 118 feet per minute, giving a discharge of 1,433,700 cubic feet per minute: a section (fig. 4) taken at Siout on the following day had an area of 6,050 square feet, with a mean velocity of 238 feet per minute, giving a discharge of 1,440,000 cubic feet per minute; but this was on the 31st of March, 1799, when, of course, the Nile was still 2.5 feet above its lowest. He computed High Nile at the same place to have a velocity of 388 feet per minute, with a sectional area of 56,000 square feet, and a discharge of 21,728,000 cubic feet; but this is subject to the same remark as to other outlets for

the flood waters. Fig. 4 gives a section of the Rosetta branch taken by Mr. Rouse at his railway bridge, Kaffir Zeit, in 1852, and again in 1854, shewing an immense erosion of the bed in that short period. The area of this section at High Nile on October 5th, 1851, was 44,600 feet; October 2nd, 1852, 35,700 feet; and October 5th, 1853, 52,500 square feet. The Low Nile of June 22nd, 1852, was 13,800 square feet; and June 23rd, 1853, 14,000 square feet.

The fall of Low Nile of 1853, between Kaffir Zeit and the sea, appeared to be about 7 feet, or .108 feet per mile: this would give a mean velocity of 110 feet per minute, with a sectional area of 14,000 square feet; the consequent discharge would be 1,540,000 cubic feet per minute, by the Rosetta Branch. This calculation is probably much in excess, as no allowance is made for inequalities of fall and bed below the section.

The High Nile area of 1853, at 6 inches per mile fall from Kaffir Zeit to the sea, gives by calculation a velocity of 320 feet per minute: the consequent discharge is 16,800,000 cubic feet per minute, by the Rosetta Branch; this calculation gives a close approximation to velocities which have been ascertained.

From the foregoing data we are inclined to estimate a High Nile flood at not less than 30,000,000 of cubic feet per minute, and it is probable that an extraordinary year has a much greater volume. In the table of the discharge of rivers we have embodied the above, and also have given a rough estimate of the area drained by the Nile. Although only very approximate, this is probably not far from the truth. The area may be taken to extend from an average line of 10° to 24° north latitude, where the river enters Egypt, and any supply from rain ceases beyond the mere occasional torrents from the mountains, forming its narrow valley for 600 miles; a district having very little rain, and in lower Egypt none.

It is curious to observe, that it would take 32 days to absorb 3 feet in depth of water over the five millions and a half acres of lands irrigated, (estimated by Girard) at the rate of 15 millions of cubic feet per minute, which is very probably the utmost which is devoted to irrigation; for a large share of the entire flood must inevitably go to the sea mouths. In the extremely dry state of Egypt, when High Nile approaches, it is not unlikely that 3 feet and upwards could be taken into the soil and stored in the canals. According to the supply taken in Lombardy it would take 120 days to give a total depth of 3 feet of water; it is therefore probable that at least 3 feet is consumed, and this quantity agrees with the general height of inundation and elevation of the minor dykes above the cultivated lands.

Assouan, at the foot of the first cataract, is 365 feet above the sea, being 583 miles above Cairo, whose plain is about 66 feet above the sea. The mean fall of the valley is therefore about six inches per mile, which represents probably with sufficient exactness the fall of *High* Nile. The surface fall of *Low* Nile probably follows the law of all other rivers that flow in their own alluvium; being in flat pools with very small velocity succeeded by short intervals of rapid fall. The inundation is about 63.5 feet above the sea at the apex of the delta, 30 miles below Cairo, giving a fall of 2.7 inches per mile between these places. When High Nile is 70 feet above sea at Cairo it raises ordinary sea level at the Damietta mouth about 3.5 feet, giving a mean fall of about 5.36 inches per mile; but intermediate parts vary from 7 to 2.7 inches per mile. The levels shew an increase of fall, in flood time, on entering the delta, like that of the Po. (See Tables of the Po, and plates XIII. and XIV.) Quatrelle on the Po, 12 miles above Pontelagoscuro and Ferrara, represents the apex of the delta of the Nile.

High Nile floods about 36 feet at Esneh, 100 miles below Assouan;

30 feet at Queneh, 190 miles from Assouan; 33 feet at Siout, 350 miles below Assouan; 28 feet at Memphis, which is 13 miles above Cairo, where the flood is as follows:—

	Year.	Day.	Height above the Sea. High Nile. feet.	Low Nile. feet.	Maximum Rise. feet.
At Cairo...	1799	Sep. 23.	68.63	46.17	22.46*
	1800	Oct. 4.	72.25	,,	26.08†
	1846	Oct. 10.	68.14	,,	21.97
	1847	,,	71.46	,,	24.29‡
	1851	,,	72.32	,,	26.15
At Memphis	1851	,,	78.00	50.40	27.60§
At Kaffir Zeit ...	1851	Oct. 5.	32.32	...	...
	1852	Oct. 2.	26.82	9,55	17.27
	1853	Oct. 5.	34.43	7.27	27.16

In comparing the value of the flood of these particular years, it may be useful to bear in mind, that when High Nile is only 17 feet above Low Nile *at Cairo*, the inundation is disastrously deficient; when the difference is 28 feet, the flood is equally disastrous from excess.

The cross sections of the Nile vary greatly from the nature of the sands and friable soil in which the River flows: it is perpetually undercutting its banks until they fall in and fresh slopes are thereby formed or more direct channels are created. The sections on plate XV. shew clearly the kind of changes that take place. The slopes at Manfalout (fig. 3) were about two to one on both sides of the river, with a mean velocity on the 27th March, 1799, of 118 feet per minute; the slopes at Siout (fig. 4) were three to one on one side and sixty to one on the opposite side, with a mean velocity on the 28th March, 1799, of 238 feet. Girard attributes the flat side to its being composed of soft matter deposited from recent erosions elsewhere.

The bottom of the Nile and all deep cuts in Egypt are said to be sand, without exception, and the slopes indicate this; many of the great artificial canals have failed from the running quality of sands in the lower cuttings. The section fig. 4 has a slope of about thirty to one; the changeable character of the bed is strongly shewn in this section, which between June, 1852, and January, 1854, had about 900 feet in length removed to a depth of 10 feet, giving an increased sectional area of 9,000 square feet below the mean level; this was promoted by some railway works erected on the banks in the interval; but it is a proof of the extreme mobility of the soil.

The canals which have been originally cut by the hand of man, have side slopes of about one in fourteen.

AS TO MODE OF IRRIGATION AND DEPTH OF WARPED LAND OF EGYPT, AND THE RISE OF LAND AND EXTENSION OF THE DELTA DURING PAST AGES.

Fig. 5, plate XV. gives a section taken near Siout for about 11,000 feet on a straight line from the river towards the Libyan mountain; it resulted that the plain was nearly horizontal, falling about 1 in 3,000 from the river bank (which is generally the case with flooded lands), and that its general level was 29 to 30 feet above Low Nile. This point, it

* Considered low.
† Considered high
‡ This was the 24th cubit mark.
§ This was an average of 3.5 feet above the general surface of plain at Memphis, which is 13 miles above Cairo.

will be observed, is at Siout, and does not agree with the mean level of High Nile before referred to as 24.6 feet at Cairo. It may be taken as a rule, that *the particular height of a plain formed by recurrent floods at any given point is always governed by the mean height of the flood at that point.* The *mean height of flood* is again ruled by the local fall of the valley, direction of stream, character of soil, and consequently area of water way, and greater or less frequency and severity of bends.

Of all the great works of Egypt, the canals of irrigation are probably the most ancient; they are taken off at various points on either bank of the Nile, and carried out as the level will permit, up to the borders of the Desert. There are recurrent transverse banks which cut the valley obliquely; they commence at the desert and terminate on the river Nile, crossing the main canals, so that, when closed at any point of intersection the water conducted by the canals rises until it attains the level of the river at the point of derivation. Thus the whole space, comprised between the intake of the canal and the transverse dykes (banks) forms, during inundation, an immense pond. When one of these spaces has been sufficiently watered, the barrier across the canal is cut through, and another area is covered in the same manner up to a second dyke; the same kind of operation is frequently carried on by an intake of water direct from the Nile. The valley of Upper Egypt thus in floodtime is a succession of ponds, in steps below each other, following the gradual fall of the valley of the river itself. The transverse dykes are from 3 to 5 feet above the land, which is always from 24 to 30 inches higher on the up-stream than on the down-stream side of the dyke. When the valley opens out towards Lower Egypt, the canals become of very large character, and similar to the Nile itself, and the embankments are on an immense scale.

When the canals are filled at High Nile, they are closed by a bank of earth at the intake, and also at all other points where the transverse dykes cross them; this operation prevents the waters from flowing out at Low Nile, and they are thus preserved for artificial irrigation and other uses during the spring and summer months. The water-wheels, screws, and other contrivances used for this purpose on the Nile are among the earliest recorded peculiarities of the valley. Girard found the water of an irrigation canal, near Siout, was only 16 feet below the plain, in March; while the Nile was about 30 feet below same level; it is thus not only the immediate warping of irrigated lands by High Nile which is so beneficial, but the after-store of water always at hand for use in a rainless country.

The banks are generally just above flood level, and form roads or paths, by which the inhabitants pass between the villages, which themselves stand upon ground raised by the refuse of the inhabitants into small hills.*

In the delta there are very great artificial canals issuing from the Rosetta and Damietta branches, which again supply smaller channels, and across these are the dykes traversing the country in every direction. The flood waters not used, finally lose themselves in the lakes and marshes on the Coast of the Mediterranean.

It has been considered that the Nile in flood has the power of depositing $\frac{1}{120}$th part of its volume, but this kind of estimate is excessively vague. It

* On fig. 5, the boring made by Girard through one of these dykes, shewed a depth of 12.8 feet of made ground, based on pure Nile mud. This made ground is a regular feature of Egypt; it is caused by the gradual raising of the embankment, as the plain has been warped up by successive deposits of ages,—in secula seculorum.

is certain that the colour of its waters is seen far out at sea, and potable water may be taken up, more than three miles from the sea mouths, at High Nile. Girard considered that the irrigated lands of Egypt were about 5,500,000 acres; this immense area for deposits ought to have a very sensible effect in controlling the seaward extension of the delta, strained as the waters are by artificial pounding, compared with rivers such as the Po and the Rhone, which are scarcely permitted to deposit. It must, however, be recollected that the character and amount of matters carried, are very different in one case from the other. The Nile flood is undoubtedly generated by a monsoon, similar to that which falls so heavily on the mountains of the Indian Peninsula, in a latitude parallel to the sources of the river, where the torrents are of the most destructive character; the mere grinding together of rocks in floods, formed by a rainfall of 3 to 9 inches per diem in hill country, is sufficient to produce immense quantities of sand; of course, where tertiary or valley formations are subjected to tropical rains, the presence of fine mud requires no theory.

At Siout and above, the depth of Nile sediment in its pure state, was found by Girard to be very variable, but on an average it seems to be about 10 feet; below this there was a mixed character of Nile mud and grey micaceous sand, and on an average the depth to water was about 21 feet below the plain, so that as water generally existed in pure grey micaceous sand, we may consider that this pure material varied from between 10 and 21 feet below the surface. Mr. Horner's borings on the other hand, at Heliopolis, were about 28 feet to water, through about 20 feet of Nile sediment and of other beds (below the top stratum which is always *pure* Nile mud), which were generally mud and grey sand; but when water came freely there was strong evidence that sand beds were reached or were very near, although the pure Nile sand was not reached so frequently, or at such small depths, as at Siout.

At Memphis the plain was about 3.5 feet below High Nile of 1851, of which the rise there was 28 feet; water was reached at 17 feet below the plain; mud and sand mixed, or pure beds of sand were generally found 10 to 14 feet below the surface. This variation in the borings is remarkably similar to the dredgings taken by Captain Spratt off the coast of the delta; the results have also the usual generic character of valley deposits, in the capricious variations of the beds beneath the upper alluvium. (*See fig.* 5.)

Girard attempted to ascertain the depth of the Libyan rocks below the plain of the Nile at Siout, and in *fig.* 5, he found that there was pure sand for 16 feet below the bottom of the pits near the river; or, in other words, that the sand did not cease at the depth of 36 feet below the plain in the middle of the valley, below which he had no means of boring. He sunk a pit about 900 feet from the edge of the cultivated plain, at a place where the ground was of the calcareous gravel and rolled flints of the desert, being 8.5 feet above the land formed by the Nile; the result gave beds of yellow sand and clays, and at bottom a depth of 4 feet of sands and gravel and rolled flints, terminating (at 13.5 feet below the plain) with the calcareous beds of the hills Girard's conclusion was, that the lower beds of the Nile deposit, are probably heavier gravels, reposing on the calcareous rocks inclining from the adjacent hills; this remark applies to Upper Egypt.

The deepest borings taken at Mr. Horner's instance, at Heliopolis, near Cairo, gave a depth of 59.8 feet, where the ground was 67.30 feet above the sea, so that the boring was down to within 7.4 feet of sea level; the last 11.5 feet of the boring was the pure sand, with occasional bits of pottery and brick. Similar borings at Memphis gave a succession of Nile deposits for 40 feet. The usual mud and sands, with

bits of pottery and brick, were still brought up with the tool at the bottom of the holes; this occurred in all the borings referred to by Horner near Cairo, but not with Girard at Siout.

The general result of these experiments appears to be that the ancient *Nile trough*, formed by the Libyan and Arabian mountains gradually deepened and widened out into the delta, forming originally the *firth* or sea mouth of the trough. The first deposits were evidently sand throughout the Nile, *from the Cataracts to the Delta*; but from analogy we should opine that heavy gravels may occur beneath these sands in the upper valley. These basement sands are distinctively silicious, precisely identical with those now forming the Mediterranean coast of the delta. It is in the nature of things that the deposits must have been deeper at the lower than at the upper end of the river, and this is shewn strongly by the borings. Whether the fragments of pottery were deposited in situ in the Memphis and Heliopolis borings, or were brought down by floods, is doubtful; but seeing that Capt. Spratt found bits on the sea coast to windward of the Rosetta mouth, brought down by every successive flood from middle or Upper Egypt, it is highly probable that Mr. Horner's fragments were thus deposited.

From a careful perusal of Mr. Horner's investigations, I see nothing to refute the clever arguments of Girard, by which he arrived at the conclusion, from buried monuments 2,000 years old, that the mean secular rise had been .433 of a foot, or say 5.2 inches at Assouan, and .394 of a foot, or 4.7 inches per 100 years at Cairo. This would give from 4,000 to 6,000 years for the present depth to have been accumulating after the sand period had gradually closed; this small length of time is not inconsistent with a far longer period for the strata of the delta to have been in progress of collection. The rise of the sea bed of the Mediterranean along the shore of the delta, has but little relation to that of the upper part of the Nile, where the land is 400 feet above the sea, and only six to ten miles in width; nor is the depth of 60 feet without a bottom near Cairo much proof that the depth of deposits is not very much greater; nor, on the other hand, is there any proof that there may not have been bars of older rocks across the valley at some point or points, such as the apex of the delta, or nearer Cairo, for instance. Pure Nile sands are now being deposited 20 miles out from shore in 240 feet of water, and Nile mud and sand mixed are found up to 14 and occasionally 20 miles from shore, in depths ranging from 200 feet at 14 miles, to 700 feet at 20 miles of water; so that there will be at some period, at least 240 feet up to 700 feet in depth of Nile deposits, without any necessity for much raising of the Nile or its banks at Cairo on hydrodynamic considerations: although the formation of 240 feet of new beds, in a distance of 20 miles seaward to the present mouths, would involve only about 9 feet of rise in the water to give the same power of discharge to the river, yet additional erosion of the Rosetta and Damietta branches, or formation of a new one, would remove any necessity for this raising of the Nile. According to Girard's estimate, it would take 2,300 years for the valley of Egypt to be raised 9 feet at Cairo, where it is still narrow; how much larger a period would be required where there is the vast area of the delta for deposits!

The seaward extension of the delta would appear in the case of the Nile, from the causes above suggested, to be progressing at an extremely slow rate, the area for deposits being practically unrestricted, and the prevalent winds affording 300 miles of leeward shore and sea bottom to receive the Nile drift. It is most useful for the engineer to apply these facts, which have to such an extent the record of past ages, afforded by no other river. Alexandria, for example, still continues

a good harbour, after an existence of 2,200 years (while others of a few years have been lost, or only struggle for an existence), simply from its position being to windward of the Nile; while, therefore, it is prudent to contemplate in some cases a rapid progress of effects in hydraulic works, it is equally wise to discriminate where progress may be marvellously slow. In the one case engineering works may be success, in the other failure may be a certainty.

It is argued by some that the Nile delta advances from 9 to 10 feet per annum at the present day; but the mere littoral advance does not afford an exact criterion of the actual amount carried down from the basin, which in this case is probably superior to that of any other river; in the first, because it has such an immense depositing area in Egypt before reaching the sea; secondly, because of the great extent of under water shoal receiving deposits; and thirdly, because the prevalent winds acting on the sands and mud are continually carrying them shoreward and leeward. Captain Spratt considers that the Nile does not deposit, *per se*, more than 12 miles in breadth at each mouth, at which point the depth is from 120 to 150 feet in depth, nor does any Nile deposit exist more than that distance to westward of the Rosetta mouth. I apprehend that he considers the remainder of these immense submarine Nilotic deposits are carried to the leeward by ocean currents and winds, and he asserts that there is proof of the sand being drifted in 8 or 10 fathoms water. It is not easy to conceive that there can be much strict diffusion of High Nile water beyond this distance.

With his remarks on the Nile delta, Captain Spratt gives some interesting particulars of the delta of the Danube, which is estimated by the late commission to have advanced about an average of one mile (half a mile to one mile and a half) in 26 years past, for a width of 12 miles in front of the Kilia mouths. This amounts to an increase seaward of 203 feet per annum, and an increase of 295 acres of delta per annum. The amount of deposit in suspension in ordinary summer floods when solidified is about $\frac{1}{2400}$ of the volume of water: and at periods of average flow $\frac{1}{33000}$.—(*Hartley's Report.*)

The surface of the Danubian delta has about 5 inches per mile fall towards the sea. The surface of the river has a fall of about 3 inches per mile, with a velocity of 2½ miles per hour, during ordinary summer floods; the surface fall is about 1½ inch per mile, with a velocity of 1 mile per hour, when the water is low.

The sea margin or base of the delta is, in the case of the Rhone, 80 to 100 miles; that of the Po is 70 to 90 miles; that of the Nile upwards of 200 miles; but if it be taken to reach Syria, as much as 300 miles in length.

COMPARISON OF THE PO WITH THE NILE AND OTHER RIVERS.

The basin of the Nile is probably fortyfold that of the Po; the monthly heights at Khartoum shew more gradual rise and more sudden fall than at Cairo. The maximum flood discharge at any one time does not exceed threefold; but the time of flood is much longer than that on the Po. This discrepancy arises from the more periodic and tropical character of the Nile floods, and from the very great distance traversed by the waters before flowing through Egypt. Length of distance on river courses always equalizes floods, spreads them out in time, and renders them more uniform; in fact their flood condition renders them compensating, like immense lakes. If we were to take the Nile at a point about 2,200 miles

from the Mediterranean, we should possibly approach to parallel conditions in these two rivers, with the exception of the great difference of climate. It is not, therefore, remarkable that the deposits and their stratification in the valley of the Po are as irregular as those of the Nile are uniform. Detritus in the one case has been ground and sifted through 2,500 miles of rapid course from table lands, whereas the valley of the Po is an immense flat basin at the foot of most precipitous mountains; a large portion of the feeders being torrents which debouch at once into the flooded area. This torrential character and propinquity of mountains to the sea mouth therefore, to some extent, afford a stronger effect in transporting massive detritus to the sea, than the opposite conditions of the Nile. In this class of the river may be placed the Ganges, Amazon, and Orinoco. The Mississippi is similar in the length of course, and enormous extent of its basin; but absolutely the opposite to any other river in the comparatively small rainfall on its basin, taken in its entirety. Its sources being among snowy mountains, afford considerable rainfall, but they are in a high latitude; the great interior continent, and the flat slopes of the country below the Missouri, and even much of the mountainous country of New Mexico, afford but small rainfall. (*See Table of Rainfall of North America.*)

THE GANGES.

INTRODUCTORY REMARKS.

This river is still without an historian; the best notice of it up to the present moment is by Major Rennel in the Philosophical Transactions for 1781. The Ganges, combined with the Burrampootra, drain the vast range of Asiatic Mountains between the head of the Indus and the sources of the Irrawaddy; and some of its branches drain a great portion of central India, even to the mountains in the north of the Bombay Presidency. The length of main river is 1,500 miles, and the area drained is not less than 700,000 square miles. Its lowest time at the head of the delta is April, and at the end of that month it commences to rise about an inch per diem for the first fortnight, it then augments to 2 or 3 inches per diem before any rain falls in Bengal; when the rain becomes general the rise is about 5 inches per diem. Rennel considered the rise at Allahabad to be from 30 to 45 feet; at Jellingy the rise in May was 6 feet, in June 9.5 feet, in July 12.5 feet, and in the first half of August 4 feet, making a total rise of 32 feet; at Dacca the rise in May was 2.4 feet, in June 4.5 feet, in July 5.5 feet, and in August 1.9 feet; total 14.3 feet. At Custec the rise is 31 feet at 240 miles from the sea; at Luckipoor, near the mouth, the rise is 6 feet, like it is at Calcutta. About the middle of August the waters stand awhile, after which the decrease is 3 to 4 inches to the end of September; 3 to 1½ inches per diem to the end of November, after which the fall is about half an inch per diem until February or March.

At Calcutta there is a mean difference of from five to six feet in the tide level between the periods of drought and flood; this will be seen in a diagram, plate XVII., whereon a year's springs and neaps are projected, offering a curious development of the law of tides when altered by swelling waters; a more particular description of these tides will be found in Division III. (*See The Hoogly.*)

FLOODS AND RAINS.

As the floods of the Ganges arise secondarily from diffusion of rains over a very broad area down to the very mouths, the effect is entirely different from the rise of the Nile, the flood of which proceeds chiefly from rain and snow near its sources. The rains appear to commence at Darjeeling in May (but sometimes in March) and terminate in September or early in October; at Patna they commence in June and cease in October; at Calcutta they commence in May and cease in October. In comparing these facts with the rise of the Ganges, we may safely conclude that the early swelling of the river dates from the melting of snows as the season advances into March; but the Soane, Chumbul and other rivers have probably a shorter rainy season, extending from June to September. The tables of rainfall shew that the period of flood waters must vary considerably; Rennel notices that in 1774 the floods kept up a month after their usual time. (*See Division IV., Rainfall of India.*) In the immense flat plains of the Ganges and its delta the local rains are sufficient to cause inundation independent of the overflowing of the river itself, and as the banks are always higher, owing to being exposed to greater amount of warping, the low country is frequently under water before the river has actually overflowed its banks. When this finally occurs the extent of flood water is almost the largest

in the world, for the sun may be seen to rise and set in the vast inundation. The fall of the Ganges valley is very similar to that of the Nile, and the delta has great general likeness, except in the much greater number of arms and creeks and sea mouths into which the Ganges is divided; the similarity arises from the same primary laws which regulate the flow of water. Rennel found that sixty miles of the plain had nine inches fall per mile, and the windings of the river would reduce this to four inches for the surface water. Below the Jumna the width in dry season is on an average three-quarters of a mile with a depth of 30 feet, and a velocity of about 240 feet per minute; in inundation this width is increased occasionally to 7 and 9 miles wide (Boglipoor), and the velocity in the deep chanels is 440 feet per minute, but the inundation velocity is about 44 feet per minute. From the original surveys of the East Indian Railway between Calcutta and Rajmahal, made by Mr. C. Greaves, C.E., it appears that the fall of the Bhaugirutte, between Rajmahal and the Mirzapore creek of the Hoogly, is 3.373 inches per mile, on the length of 190 miles; but the slope of the valley is 4.970 inches per mile on a direct course of 129 miles.

The deposits forming the bed and banks of the Ganges are perpetually in course of erosion and re-formation; when the river current has commenced to cut out a bend, the advance proceeds at the rate of one mile in 10 or 12 years. Rennel observed the mouth of the Jellingy river move downwards three-quarters of a mile in 11 years; and by two surveys of a part of the bank of the Ganges, he found that 1½ mile had been removed in 9 years. The erosion is aggravated by the dry seasons, when the steep and undermined banks become cracked, and fall off from want of sufficient slope or tenacity. The section of the Nile and curves of the Po shewn at plates XIII. and XV. describe very nearly the state of the Ganges, which, however, is on a much larger scale in any respect than either of those rivers. The inundated lands and delta of the Nile is everywhere more or less artificially embanked, the Ganges on the other hand has no proper embankments other than the minor arrangements of the cultivators of rice grounds to retain the exact height of water necessary to float the shooting plants.

THE DELTA.

The delta of the Ganges can scarcely be separated from that of the Burrampootra, for the waters of both mingle in flood season, the total area can be little short of 300 miles sea margin, and 200 to 250 miles to the apex. The sea margin has no less than eight important creeks or rivers, some of which always carry water, others only in flood time, and others are tidal without any present communication with the main river. Each of these eight openings is thought to have been in its time principal outlet of the Ganges.

Rennel states that there is no appearance of other than deposited mud between the Tiperah hills and the province of Burdwan, nor on the north up to Dacca and Bauleagh. In all the sections of the numerous rivers of the delta, nothing but sand and black mould appear in regular layers until we come to the clay which forms the basement bed. There is no substance as coarse as gravel, until we reach 400 miles from the sea where a rocky point projects, and in all parts of the delta, whether remote from the great rivers or otherwise, the soil is either red, yellow or deep brown.

The flow of the Ganges estimated by Rennel will be found in the Table of Rivers.

FLOW FROM SEWERS AND WATER SUPPLY IN THE METROPOLIS.

In contradistinction to the foregoing subject, the flow of sewers is of course wholly artificial and dependent greatly upon the supply of water which may be afforded in each particular case. There is also the general fact that natural rain or streams are carried off in a highly different manner by sewers, so that even the natural springs themselves are altered in character and become in towns almost invariably mere feeders to the bottom of sewers, which offers the line of least pressure for their exit. It is thus probable that the City of London was well supplied with springs between the Fleet and Ratcliffe along the bed of gravel which forms the Northern bank of the Thames, and the upper districts had many excellent conduits or water fountains, all of which have now disappeared excepting in name.

There was only partial information on this subject up to 1852, when Mr. Haywood, the Engineer of the Board of Works of the City of London, made the most accurate measurements of all the chief sewers in that district for a continuous period. Since this, gaugings of other great metropolitan sewers were taken by Mr. Bazalgette, and later, a more extensive series was taken by Messrs. Simpson, Galton and Blackwell, when reporting on the plan for main drainage of the metropolis. The three following pages give the result of their investigations both for the flow of sewage and the supply of water, which have a close relation—it is unnecessary to describe these tables, as they have the entire facts condensed thereon from several tables issued in the Blue Books of 1857, containing the reports and long discussions which took place at the time. The total flow of sewage at that time on the North and South of the Thames, appeared to be about 36 gallons per diem, per head of population, excluding rain, the water supply was about 30 gallons per head. This difference of six gallons may be attributed to springs and artificial pumping, of which the aggregate quantity must be considerable, from breweries and other large establishments having deep wells. The total surplus quantity appears to be about 1,770 cubic feet per minute, which if divided over the 70 square miles, is about 25 cubic feet per minute, per square mile, or nearly six inches per annum, distributed on the surface; this would indicate that the effect of rain is felt indirectly in the gaugings, as the supply from wells and springs above would scarcely amount to that quantity.

The gaugings in the subsequent tables were made in the spring months of 1857.

The authorities from whom we are now quoting observed that the Savoy Street sewer discharged on the 20th of June, 1857, about twenty times its minimum and six times its ordinary maximum flow; the rain on this day was .9 of an inch, between 12 at night and 1.45 a.m., and ·08 more fell before noon. The ordinary and maximum flow in three important sewers on the morning of the 20th of June was thus:—

	Area.	Mean ordinary flow	Maximum flow on 20th June.	Mean flow per acre.	Maximn flow per acre.
	Acres.	Cubic Feet per min.	Cubic Feet per min.	Cubic Feet per min.	C. Feet per min.
Norfolk Street Sewer	79	21	58	1.11	3.05
Essex Street Sewer	92	71	490	.77	5.25
Northumberland Street Sewer	370	320	1410	.86	3.75
Savoy Street Sewer.....	152	...	3100	...	20.50

The maximum flow appears to have followed the rain within a very short time, as, indeed, was to be expected, for the areas are small and the slope of the sewers very rapid; the streets are of a good class, and the houses generally well drained: this applies especially to Northumberland Street Sewer, which drains Regent Street. The maximum flow in Savoy Street Sewer took place at 2 a.m.; the flow fell to 1,060 cubic feet at 2.15, and to 638 cubic feet at 2.30 a.m.

By gaugings of various sewers in Westminster, made in the summer of 1845, Mr. Hawkins, C.E., reported that the mean summer discharge of the Westminster district, *urban* and *suburban*, was .277 of a cubic foot per minute per acre; the urban only was .876 of a cubic foot per minute per acre.

The general conclusion at which the referees arrived, in reference to the Metropolis, was, that the great intercepting scheme should be arranged to carry off from urban districts with about 80 persons per acre, about two-fifths of an inch of rain during the eight hours of maximum flow; this opinion has relation as much to questions of dilution as to the actual quantity necessary to be intercepted for abstract purposes of drainage, for a very large quantity of heavy rain would still have to flow away by other channels. This fact should be borne in mind in all systems of artificial drainage, for the surface flow of water is great, with heavy rain; in point of fact, heavy storms cannot get into the best system of sewers, before they have made their way elsewhere. This natural operation is indeed generally not without benefit, and the only cases in which it cannot operate are those of absolutely flat areas, which, practically, do not often occur in closely built towns, sewered in the modern fashion; certainly such cases ought to have the principle of interception applied to them in the broadest acceptation of the term.

In some of the earlier blue books upon the question of size of sewers, it was suggested that they should be made large enough to carry one inch of rain per hour, *i.e.* 60 cubic feet per minute per acre; this is the calculated quantity which ran in some London sewers in the thunder-storm of August 1st, 1846. The flood levels given in evidence, generally indicate a discharge from thunder-storms of 25 to 35 cubic feet per minute from each acre of urban drainage; this is equal to 1.66 and 2.33 inches of rain in 4 hours—a quantity which it would be perfectly extravagant to attempt to carry off artificially on a large scale.

The following tables shew the oscillation of flow in the sewers for each portion of the 24 hours, and likewise the variation in demand upon the water companies during the same periods, with the relative quantities for each day of the week, and for summer compared with other ordinary seasons. This information was furnished to the referees by the companies, and contains matter in a form never before obtained on so complete a scale. The tables will be applicable generally to town supplies, where the chief difficulties and expenses of distribution exist in the variable character of draft on the mains.

METROPOLITAN SEWERS.

SUMMARY OF THE FLOW OF SEWAGE IN EACH DAY,

With the corresponding quantity per Acre, and per head of population, of the Area drained; as gauged in 1857 by the Referees on the Metropolitan Drainage.

Principal Sewers.	Area Drained	Population per Acre.	Population in District.	Flow of Sewage.	Flow per Acre	Flow per Head of Population.
	Acres.	No.	No.	Cube feet. ℔ diem.	Cube ft. ℔ diem.	Cube ft. ℔ diem.
Counter's Creek, Kensington Branch	1,807	23	41,300	353,800	196	8.6
Ranelagh	4,150	32	132,100	924,894	223	7.0
King's Scholar's Pond	1,820	92	167,700	1,203,830	661	7.0
Northumberland, Savoy, Essex & Norfolk Streets.	633	253	160,000	783,322	1,206	4.8
Fleet	4,220	57	239,000	1,741,775	413	7.2
London Bridge	2,250	86	194,750	1,318,830	586	6.4
Ratcliffe Cross	1,098	135	148,230	905,910	825	6.1
Upper Effra	3,650	7.3	26,850	210,030	57	7.8
Gross Estimate of Flow for Metropolis North of the Thames	31,556	62	1,963,000	11,513,227	365	5.9
Ditto South of the Thames	43,695	16	693,000	3,736,550	86	5.4
Total (exclusive of Rain)	75,251	35	2,656,000	15,208,083	202	5.8

DETAILS OF FLOW IN EACH HOUR,

Down several important Sewers, with the Gross Average Flow in fourteen Sewers in dry weather.

Hour.	Counter's Creek. S.	Ranelagh. S.	Northumberland Street.	Fleet. S.	London Bridge.	Hackney Brook. S.	Upper Effra. S.	Total Flow of 14 Sewers.
1 a.m.	9,360	18,885	8,160	36,075	25,965	28,020	6,270	194,048
2 ,,	8,520	16,350	7,845	33,645	25,155	26,940	6,030	181,108
3 ,,	8,280	15,240	7,455	32,835	24,420	26,385	5,625	174,689
4 ,,	8,205	14,624	7,335	30,540	24,435	25,650	5,220	168,959
5 ,,	8,040	12,705	7,695	30,870	24,495	25,155	5,235	166,975
6 ,,	7,920	14,205	8,130	35,550	24,690	24,570	5,385	174,081
7 ,,	10,875	19,800	14,040	51,585	37,380	25,965	5,880	225,968
8 ,,	17,100	28,755	28,275	86,805	69,000	26,250	7,005	361,899
9 ,,	20,835	35,790	38,100	103,800	81,945	28,170	7,965	464,104
10 ,,	22,500	55,200	39,315	104,295	82,980	29,220	9,240	518,877
11 ,,	25,635	53,290	34,185	124,455	89,430	30,240	10,875	552,247
12 ,,	20,295	61,485	28,545	124,635	88,380	30,990	11,670	558,990
1 p.m.	18,075	63,900	27,165	123,570	82,155	31,170	11,775	541,444
2 ,,	15,825	58,875	25,800	102,465	75,420	32,040	13,050	498,540
3 ,,	16,230	60,480	23,460	97,065	71,325	32,265	11,205	470,505
4 ,,	14,805	58,035	24,360	106,305	79,875	32,310	12,780	487,986
5 ,,	17,040	55,275	27,015	108,570	82,890	32,670	13,020	494,408
6 ,,	17,925	51,510	25,395	89,055	73,140	32,745	11,460	443,437
7 ,,	17,010	47,385	19,080	72,945	63,885	35,055	10,680	383,940
8 ,,	17,475	46,185	15,930	63,090	52,905	35,070	9,555	342,751
9 ,,	16,260	41,850	13,230	53,750	43,695	34,245	8,565	300,230
10 ,,	13,635	36,420	10,770	47,295	35,670	31,860	7,980	262,094
11 ,,	11,445	31,800	9,945	42,780	31,515	30,240	7,140	235,215
12 ,,	10,590	26,850	9,135	39,795	28,080	29,070	6,420	218,068
Total ...	353,880	924,894	460,365	1,741,775	1,318,830	716,295	210,030	8,420,566

NOTE.—The Sewers marked S. drain more or less Suburban districts.

	Quantity Cubic feet.	Per Centage.
Eight Hours Maximum Flow, 9 a.m. to 5 p.m.	4,122,997	49.
Ditto Mean Flow, 7 to 9 a.m and 5 to 11 p.m.	2,793,672	33.
Ditto Mean Flow, 11 p.m. to 7 a.m.	1,503,897	18.
Total Flow in 24 hours of the principal Sewers	8,420,566	100.

METROPOLITAN WATER SUPPLY.

SUMMARY SHEWING NUMBER OF HOUSES AND QUANTITY OF WATER SUPPLIED

By the various Water Companies in 1857.

Name of Company.	Number of Houses Supplied.	Mean Daily Supply in April.			Summer Daily Supply.			Largest supply in any one day of April. Gallons.	Per cent. of excess over Mean Daily Supply
		Cubic Feet.	Gallons.	Gals. per House.	Cubic Feet.	Gallons.	Gals. per House.		
N. Side.									
Chelsea	25,315	934,467	5,840,419	231	1,097,999	6,862,492	271	7,315,800	25.2
East London	70,876	2,380,876	14,880,475	210	2,880,000	18,000,000	254	15,915,175	6.9
G. Junction.	17,716	1,009,982	6,312,383	356	1,085,730	6,785,812	383	7,084,575	12.2
Hampstead.	6,708	203,087	1,269,296	189	223,396	1,396,225	208	.....	...
New River .	96,992	3,204,636	20,028,979	206	3,525,100	22,031,875	227	.....	...
W. Middlesex	28,409	1,074,456	6,715,350	236	1,310,836	8,192,727	288	7,785,675	15.9
Total	246,014	8,807,504	55,046,902	224 mn.	10,123,061	63,269,131	272 mn.	.....	12.9 mn.
S. Side.									
Kent	17,150	466,218	2,913.862	170	600,000	3,750,000	218	3,497,662	20.0
Lambeth ...	29,308	958,566	5,991,036	204	1,131,107	7,069,420	241	7,436,651	24.1
Southwark & Vauxhall	44,529	1,694,960	10,593,500	238	1,949,204	12,182,525	273	11,557,000	9.1
Total	90,987	3,119,744	19,498,398	214	3,780,311	23,001,945	244	22,491,313	15.3
Gross Total	337,001	11,927,248	74,545,300	221 mn.	13,903,372	86,271,076	245 mn.	.....	13.8 mn.

In addition to the above, the Trafalgar Square Well supplied 500,000 gallons per day, to the Government Offices, &c., and the Plumstead Waterworks supplied 560,000 gallons per day, to 3,150 houses.
The population on the North side appears to average 8 persons, and on the South side 7 persons to each house.

EAST LONDON WATERWORKS.

QUANTITY OF WATER PUMPED DAILY,

From 28th March to 2nd May, 1857.

DATE.	Quantity in Cubic Feet.	DATE.	Quantity in Cubic Feet.	DATE.	Quantity in Cubic Feet.
March 28	2,502,400	April 9	2,378,413	April 21	2,455,246
,, 29	1,105,582	,, 10	2,122,854	,, 22	2,410,359
,, 30	2,306,518	,, 11	2,262,558	,, 23	2,351,552
,, 31	2,398,288	,, 12	878,480	,, 24	2,402,504
April 1	2,364,845	,, 13	2,546,428	,, 25	2,463,571
,, 2	2,377,192	,, 14	2,212,995	,, 26	1,147,409
,, 3	2,396,823	,, 15	2,304,262	,, 27	2,390,949
,, 4	2,347,790	,, 16	2,332,494	,, 28	2,401,546
,, 5	1,189,140	,, 17	2,366,289	,, 29	2,401,108
,, 6	2,396,579	,, 18	2,398,913	,, 30	2,458,482
,, 7	2,397,066	,, 19	1,175,188	May 1	2,472,254
,, 8	2,372,675	,, 20	2,350,852	,, 2	2,463,354

TABLE SHEWING PROPORTION PUMPED DURING EACH HOUR OF THE DAY,

The total quantity being taken = 100.00

Hour ending.	Proportion Pumped	Hour ending.	Proportion Pumped	Hour ending.	Proportion Pumped	Hour ending.	Proportion Pumped
p.m. 7	3.41	a.m. 1	2.15	a.m. 7	4.69	p.m. 1	6.32
,, 8	3.07	,, 2	2.09	,, 8	6.75	,, 2	5.81
,, 9	2.54	,, 3	2.09	,, 9	6.57	,, 3	5.95
,, 10	2.45	,, 4	1.98	,, 10	6.53	,, 4	5.65
,, 11	2.33	,, 5	2.26	,, 11	6.40	,, 5	5.55
,, 12	2.01	,, 6	2.64	,, 12	6.10	,, 6	4.55

DETAILS OF QUANTITY OF WATER SUPPLIED HOURLY

From 5th to 11th April, 1857.

CHELSEA WATERWORKS.

Hour ending.	Sunday April 5th.	Monday April 6th	Tuesday April 7th.	Wednes. April 8th.	Thursday April 9th.	Friday April 10th.	Saturday April 11th.
	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.
7 p.m.	98,400	40,200	179,200	155,400	57,000	77,000	33,600
8 ,,	112,000	40,200	219,200	99,400	46,200	67,900	81,200
9 ,,	125,600	19,800	137,600	71,400	65,400	67,200	93,800
10 ,,	83,200	40,200	94,400	98,000	45,600	56,700	105,000
11 ,,	40,000	75,000	94,400	67,200	34,800	37,100	39,900
12 ,,	40,000	55,200	134,400	37,800	44,400	56,000	51,800
1 a.m.	52,000	13,800	92,800	155,400	43,800	56,000	51,100
2 ,,	48,800	55,200	169,600	92,400	43,200	65,100	51,100
3 ,,	48,800	55,200	91,200	121,800	63,000	54,600	34,300
4 ,,	60,000	75,000	89,600	119,000	42,600	54,600	42,000
5 ,,	60,000	34,200	169,600	205,800	52,200	44,100	58,100
6 ,,	32,000	96,000	128,400	176,400	61,800	63,700	58,100
Total Night	800,800	600,000	1,600,400	1,400,000	600,000	700,000	700,000
7 a.m.	221,000	573,000	687,000	590,000	574,000	566,000	660,000
8 ,,	203,000	543,000	642,000	550,000	550,000	526,000	630,000
9 ,,	130,000	552,000	630,000	550,000	540,000	502,000	570,000
10 ,,	110,000	573,000	630,000	490,000	535,000	502,000	600,000
11 ,,	110,000	410,000	527,000	470,000	440,000	447,000	530,000
12 ,,	37,000	421,000	458,000	344,000	392,000	388,000	300,000
1 p.m.	55,000	389,000	367,000	329,000	263,000	297,000	210,000
2 ,,	37,000	421,000	430,000	367,000	260,000	340,000	550,000
3 ,,	20,000	494,000	504,000	410,000	450,000	187,000	530,000
4 ,,	20,000	421,000	430,000	348,000	390,000	234,000	300,000
5 ,,	20,000	250,000	210,000	230,000	230,000	108,500	160,000
6 ,,	37,300	175,000	200,400	120,280	139,050	128,050	160,200
Total Day	1,000,300	5,222,000	5,715,400	4,798,280	4,763,050	4,225,550	5,200,200
Gross Total	1,801,100	5,822,000	7,315,800	6,198,280	5,363,050	4,925,550	5,900,200

SOUTHWARK AND VAUXHALL WATERWORKS.

7 p.m.	80,000	436,000	408,000	470,000	496,000	412,000	412,000
8 ,,	75,000	383,000	322,000	385,000	361,000	387,000	379,000
9 ,,	70,000	317,000	306,000	282,000	329,000	293,000	314,000
10 ,,	69,000	228,000	222,000	237,000	217,000	219,000	237,000
11 ,,	68,000	184,000	159,000	159,000	201,000	171,000	160,000
12 ,,	67,000	122,000	125,000	168,000	107,000	105,000	112,000
1 a.m.	70,000	86,000	87,000	86,000	93,000	86,000	97,000
2 ,,	86,000	92,000	91,000	88,000	96,000	93,000	101,000
3 ,,	101,000	109,000	111,000	107,000	163,000	108,000	188,000
4 ,,	125,000	296,000	301,000	298,000	303,000	297,000	352,000
5 ,,	162,000	504,000	502,000	506,000	498,000	512,000	553,000
6 ,,	231,000	606,000	601,000	604,000	647,000	598,000	657,000
Total Night	1,204,000	3,363,000	3,235,000	3,390,000	3,511,000	3,281,000	3,562,000
7 a.m.	238,000	680,000	664,000	678,000	682,000	678,000	681,000
8 ,,	274,000	679,000	681,000	683,000	679,000	682,000	698,000
9 ,,	358,000	666,000	682,000	660,000	658,000	667,000	689,000
10 ,,	421,000	594,000	592,000	596,000	602,000	597,000	596,000
11 ,,	256,000	566,000	580,000	567,000	579,000	563,000	598,000
12 ,,	212,000	582,000	568,000	582,000	601,000	597,000	603,000
1 p.m.	166,000	598,000	601,000	597,000	602,000	603,000	602,000
2 ,,	122,000	556,000	549,000	488,000	552,000	582,000	578,000
3 ,,	106,000	489,000	486,000	550,000	492,000	496,000	506,000
4 ,,	100,000	462,000	458,000	466,000	460,000	463,000	481,000
5 ,,	92,000	461,000	432,000	458,000	502,000	453,000	462,000
6 ,,	87,000	445,000	429,000	506,000	438,000	438,000	508,000
Total Day	2,432,000	6,778,000	6,722,000	6,831,000	6,847,000	6,819,000	7,002,000
Gross Total	3,636,000	10,141,000	9,957,000	10,221,000	10,358,000	10,100,000	10,564,000

Note.—As to Wells through Chalk into the Lower Green-sand.

These wells have been, without doubt, unsuccessful in the London Basin. Attempts to obtain water in this way have been recently made at Warren Farm, near Brighton, at a point about 410 feet above the sea; the well has pierced 1,282 feet of the cretaceous series, and finally pierced the green-sand at that depth, when water was met with. On the 23rd of March, 1862, or about a week after the occurrence, this had risen 700 feet in the shaft; it is probable that the permanent height of the water will not exceed high-water level.

The subcretaceous or green-sand rocks are not always productive of water. Degoussée experienced failures at Evres and Ferrières. This want of success has been more striking in this country; for instance, a well at Hastings has been sunk 553 feet; hitherto without success.

A well sunk in the Wealden series, at Warnham Court, near Horsham, passed at 142 feet into red clays and sandstone, without obtaining water. At Red Hill also, Docwra traversed the sands and loam of the green-sand series to a depth of 438 feet, when the red clays and sandstones were met with similar to the Horsham case. Both these cases were failures in rocks very similar to those met with in the Highgate borings. A bore at Stowmarket, made at a point about 250 feet above the sea, and sunk to a depth of 895 feet, was successful in obtaining water in the lower green-sand.—*(From G. R. Burnell's paper.)*

As to Mean Level of Sea and effect of Floods at Mouths of Rivers.

The law of gravitation does not permit the mean sea level to vary materially at any point of the globe where there is a free interchange of waters; high and low waters may differ considerably, owing to there being a greater tidal wave at one point than another contiguous, but the mean half-tide level ought to be the same. It will be seen by the recorded levels in various examples set out in this work, that there are small apparent differences round the coast of England, but the true mean levels may not yet be satisfactorily ascertained; we may refer, for an example of this, to the record of the tides at Holyhead, page 215; here the winter gales cause a difference of 10 inches, but this would only represent a mean elevation of 5 inches. There is certainly a tendency in the mean tide level to rise at the head of long estuaries; but where very great obstructions exist to the propagation of the tidal wave, high water reduces itself below the level of the original wave.

It has been ascertained by levelling across the Isthmus of Panama, that the Pacific and Atlantic are on the same level; in the course of the levelling for the Suez canal, it was ascertained that low water of the Red Sea and Mediterranean, at Suez and Tineh (Pelusium), are very nearly at the same level, Suez being about 1 inch lower.

The mean rise of tides at Suez is somewhat above that in the Mediterranean, but the maximum difference is not more than 31½ inches.

The rise of equinoctial springs at Suez is 7.9 above low water in the Mediterranean at Tineh, and low water at the same period at Suez is 17.7 inches below the lowest water at Tineh.

The floods of great rivers, without doubt, sensibly affect even the height of the open sea, as their waters do the character of sea water. For instance, the colour of the Ganges may be seen, at times, 20 miles out from the coast; this also occurs with the great rivers of China; Admiral Smythe says that at High Nile potable water may be taken up on the surface of the Mediterranean, out of sight of land. The greatest rise of High Nile, at its mouths, is about 42 inches; such a volume as this would probably require a fall of one inch per mile for the first 3 to 5 miles of the open sea beyond the bar.

NOTES

ON THE

TABLE OF THE FLOW OF RIVERS.—Pages 200 & 201.

The following pages give the mean, maximum, minimum, and ordinary summer flow of some of the more important rivers, and also of some minor streams, with the ratio of their flow and discharge, which may be found at other places in Division II. Some of the examples are collated from the letter-press, so as to give at one view a comparison with others, of which the data have been collected from various sources, quoted in each case. Lombardini has generally procured his account of the rivers of France from papers in the "Annales des Ponts et Chaussées," by engineers connected with their management.

It will be seen in the Tables of Flow that the mean flow of rivers varies greatly in different years, governed as they are by the varying rainfall; this will therefore affect those examples which are quoted only from certain years, or isolated observations. The minima and maxima are also subject to these remarks. Glacial rivers, such as those off the Alps and Jura, have in their "ordinary summer flow" almost the maximum of the year; but in lowland rivers this period frequently gives the minimum discharge. When examining the tables, it is necessary to have these exceptional facts in mind; they will be seen clearly by examining the flow of the Saône, Arve, Rhone—pages 157, 158, 160—and also in the article on the River Po.

The Mississippi.—The flow is given by Prinsep as taken at Natchez, about 80 miles above the Delta. At lowest ebb the breadth was 2,400 feet; depth of channel, 80 feet; mean depth being 50 feet, sectional area 120,000 square feet, and velocity about 50 feet per minute; the maximum being 88 feet. In freshes this river has at the same place a width of about 2,700 feet, greatest depth 120 feet, and mean 100 feet; with an average velocity of about 220 feet per minute.

Prinsep thinks the rainfall of the Ganges area may average 50 inches, and that of the Mississippi 18 inches: it may be presumed that the latter is somewhat too low. It is very doubtful what the exact area of the basin of the Mississippi may be.

The Nile.—The area of the basin of the Nile is only approximate. Talabot makes the mean flow of the Nile at Cairo for four years (1844-7) 6,057,000 cubic feet per minute, and represents a mean height of 10.59 feet on the Nilometer; it is a good deal less than the mean flow named in the table; both are probably far below a maximum year, for the mean flow is computed from the mean height of the year; the amount which would flow *above* that level is far greater than any discharge when the river is *below* the medium level. The Rosetta mouth of the Nile is 1,968 feet wide and 5.25 feet deep at lowest water; the Damietta mouth is 984 feet wide and 8.22 feet deep at the same period. (See article on Nile, page 181.)

The Ganges.—The quantities at Benares were taken from a section by Prinsep, 25th of April, 1829, "after a long interval without rain." The area of the section was 48,650 square feet; width, 1,400 feet; and mean depth, 34¾ feet; the mean velocity being 23.5 feet per minute. The maximum discharge at the same place is computed, when the river was 3,000 feet wide, with an average depth of 58 feet, and sectional area of 175,000 square feet, the mean velocity being about 440 feet per minute. (See Plate XVI.)

[*For continuation, see Page* 202.]

TOTAL ESTIMATED DISCHARGE;

In different conditions.

Name of River.	Area of Basin.	Estimated or Observed Discharge.			
		Mean Annual.	Ordinary Summer.	Minimum.	Maximum.
	Sq. Miles.	C. ft. per min.	C. ft. per min.	C. ft. per min.	C. ft. per min.
Mississippi	886,000	33,000,000	...	6,000,000	60,000,000
Nile, at Cairo	600,000	10,044,000	1,440,000	722,000	21,720,000
Ganges, at Benares	180,000	15,000,000	...	1,140,000	77,100,000
,, at Kot	192,000	...	...	828,000	...
,, at Sikreegulee	330,000	30,000,000	...	1,260,000	108,000,000
Cauvery, Madras	32,000	1,012,500	...	...	19,200,000
Rhine, at Lauterbourg	63,000	2,343,600	985,300	...	10,616,200
Seine, at Troyes, 1848-55	1,200	42,380	9,535	5,785	395,400
,, at Paris	17,111	529,700	241,540	158,900	3,813,800
Eure, at its mouth	2,200	...	34,000	...	1,053,000
Garonne, at Marmande	20,028	1,440,920	317,850	127,140	22,250,000
Saone, at Trévoux	11,551	1,018,000	922,300	79,770	3,825,450
Rhone, at Geneva	3,000	640,500	863,330	195,000	1,105,000
,, at Avignon	35,745	3,640,000	1,483,150	985,000	21,188,000
Ardeche, 1857	900	...	10,600	...	17,000,000
Erieux, ,,	328	...	...	...	6,350,000
Doux, ,,	244	...	...	...	790,000
Arve, at Geneva, 1856	772	266,800	423,100	...	1,270,000
Oglio and Cherio	740	158,910	76,280	42,380	678,000
Mincio	788	163,150	116,530	74,160	294,500
Adda, below L. Como	1,670	396,210	72,040	48,730	1,695,000
Ticino, below L. Maggiore	2,420	646,230	224,590	152,550	3,813,800
Po, at Pontelagoscuro	26,754	3,644,300	1,379,330	453,420	13,251,000
Tiber, at Rome	6,458	618,230	391,970	33,900	3,629,470
Severn, below Gloucester	3,890	...	33,110	...	751,250
Lee, at Feilde's Weir	444	13,530	8,450	4,120	598,070
Thames, at Staines	3,086	100,000	45,000	35,000	400,000
Medway, at Preston	481	...	2,520	2,209	140,000
Nene, at Peterborough	620	...	5,000	2,000	...
Shannon, at Killaloe	4,571	...	54,852	...	4,388,000
Bann, 1856	2,205	209,150	110,430	69,800	662,400
Brosna, Ferbane, 1852, 6	446	44,150	26,590	8,300	238,400
Robe, Mayo, 1851, 52	109.4	14,100	4,550	1,050	115,660
Rivington Pike, 1847, 8	16.25	2,850	2,000	394	6,425
Loch Katrine	71.6	26,170	21,100	7,000	150,000
Loch Lubnaig, 1847, 54	69.7	25,050	17,480	1,780	328,000
Teith, at Deanston, 1826	191.0	...	3,820	2,268	...
Brockburn, 1852	4.3	900	392	...	...

DISCHARGE IN RELATION TO AREA DRAINED;

With the Depth run off that Area.

Discharge per Square Mile.				Ratio of Mean Discharge taken as 1.00			Depth run off per Ann'm	Authority.
Mean Annual.	Ordry. Summr	Minimum.	Maximum.	To Ord. Summr	To Minimum.	To Maximum.		
C.f.p. min	C.f.p. min	C.f.p. min	C. ft. per min.	1 to	1 to	1 to	Inches.	
37.25	...	6.77	67.72	...	0.18	1.82	8.4c	Approximate
16.74	2.40	1.20	36.20	0.14	0.07	2.10	3.78	Girard
83.33	....	6.33	428.33	...	0.08	5.14	18.8c	Prinsep and others
...	...	4.31	...	...	...	...	...	,,
90.91	...	3.82	327.27	...	0.04	3.60	20.51	,,
31.64	...	...	171.23	...	...	18.96	7.14	Baird Smith; approx.
37.80	15.89	...	149.52	0.42	...	4.53	8.53	DefontainesPts. et. Ch
35.32	7.95	4.82	329.50	0.22	0.14	9.33	7.9c	Ponts et Chaussées
30.96	14.12	9.29	222.90	0.46	0.30	7.20	6.98	,, ,,
...	15.46	...	748.64	...	...	...	...	St. Clair. Pts. et Ch.
71.95	15.87	6.35	1,110.95	0.22	0.09	15.42	16.23	Lombardini
88.13	79.85	6.91	331.18	0.91	0.08	3.76	19.9c	Hyd. Commission
213.50	221.11	65.00	368.33	1.03	0.30	17.25	48.2c	Dufour and others
101.33	41.49	25.74	592.75	...	...	...	22.86	
...	11.78	...	18,888.89	...	...	...	...	Mardigny, Pts. et Ch.
..	...	...	19,359.76	...	...	...	...	,,
...	...	...	3,237.00	...	...	...	...	,,
345.60	548.06	...	1,645.08	1.59	...	4.76	78.72	Paul Chaix
214.74	103.08	57.27	916.22	0.48	0.27	4.27	48.45	Lombardini
207.04	147.89	94.11	373.73	0.70	0.45	1.80	46.71	,,
237.25	43.14	29.18	1,014.97	0.18	0.12	4.28	53.52	,,
267.04	92.81	63.04	1,575.95	0.35	0.24	5 90	60.24	,,
136.21	51.55	16.94	495 29	0.38	0.12	3.63	30.73	,,
95.80	60.69	5.25	562.01	0.63	...	5.87	21.62	Venturoli
...	8.51	...	193.19	...	...	...	...	Beechey
30.47	19.03	9.28	1,347.00	0.62	0.30	44.21	6.9c	
32.40	14.58	11.34	129.66	0.45	0.35	4.00	7.31	
...	5.26	4.59	291.06	...	...	...	...	Rennie, 1787
...	8.06	3.26						
...	12.00	...	960.00	...	...	...	...	Approximate
94.85	50.08	31.65	300.41	0.53	0.33	3.17	21.44	
98.99	59.62	18.61	534.53	0.60	0.19	5.40	22.38	
128.88	41.59	9.60	1,057.22	0.32	0.07	8.23	29.14	Betagh
175.38	123.08	24.25	395.38	0.70	0.14	2.25	39.8c	R.Stephenson'sReport
365.50	294.69	97.76	2,094.97	0.81	0.27	5.73	81.7c	Bateman
359.39	250.79	25.55	4,705.88	0.70	...	13.09	81.33	Leslie, Bateman
...	20.00	11.87	...	...	...	...	...	Bateman
209.20	91.63	...	...	0.44	...	...	47.4c	

Notes, &c., *(continued from Page 199.)*

The gauging at Kot, near Bulleah, was taken by Lieut. Garforth, B.E., in the first week of May, 1850, "when the river was at its lowest." The sectional area was 5,876 square feet, width at water line 1,125 feet, mean velocity 141 feet per minute. The maximum velocity in mid-channel was 198 feet per minute, which greatly exceeds that of places where the river is deep; the maximum depth in this section was 9 feet 5 inches in a narrow place only 120 feet in width, the remainder of the section generally varying from 4 to 6 feet in depth.

Sikregulee is 30 miles above the delta; the Ganges has here received the Gogra, Gunduk, Koosee, Sone, and other rivers, whose united volume is frequently more than that of the Ganges proper, Jumna, and other affluents which form the river at Benares. The gauging in the table was taken on the 9th of March, 1829; the breadth was about 5,000 feet; the depth, 3 to 5 feet; the sectional area, 15,000 square feet; the mean velocity about 86 feet per minute. At the top of the freshes the breadth of the river is about 10,000 feet; mean depth, 28 feet; and sectional area, 280,000 square feet; the mean velocity being about 440 feet per minute, and maximum about 600 feet per minute.

The Seine.—The area of this river is in great part oolite, green-sand and other tertiary formation. The quantities given for Paris are from registers between 1777 and 1825.

In August, 1858, the flow fell to 135,000 cubic feet, or 8 cubic feet per minute per square mile; this was the period when the Rhine and the Danube were so excessively reduced by a long drought.

The Thames was also very low in the summer of 1858.

The Seine at Troyes is the mean of eight years, 1848-56. The maximum was on the 30th January, 1850. The mean of all the floods for the period was 266,994 cubic feet, or 220 cubic feet per square mile.

The Rhone.—This basin is highly mountainous and glacial; the river is said to have an ordinary discharge in the later summer months, of 529,000 cubic feet per minute above Lyons; 678,000 below Lyons after the Saône has joined; 878,000 cubic feet below the Isere and Drôme; and 985,000 at Avignon. The great flood of May, 1856, discharged at Valence for eleven days, an average quantity of 15,000,000 cubic feet per minute, or about 500 cubic feet per minute per square mile; this would represent a depth of 10.23 inches run off in the eleven days, or 0.93 inches per diem; the maximum depth run off on one day must have greatly exceeded this quantity.

The Ardèche.—This River, and the Erieux and Doux, drains precipitous mountains, which are celebrated as being subject to excessive rains. Joyeuse is situate in this district. (See Rainfall of France, stations, Privas and Viviers; also page 161.)

Loch Lubnaig.—The minimum flow off this district was in 1847, 1,780 cubic feet; on July 18th, 1848, it was 2,445 cubic feet; on the 17th and 18th June, 1849, the minimum flow was 2,003 cubic feet per minute.

The Teith.—This district is highly mountainous; the river is formed by the water flowing from Lochs Lubnaig and Katrine. The quantity is for the month of May, June, July and August, 1826, when there was excessive drought for 100 days; the total quantity run off the area of 191 square miles was only 1.24 inch for that period, giving a mean daily flow of .0124 inch in depth. The flow in May was 6,950 cubic feet per minute; in June, 2,268; in July, 3,117; in August, 3,154 cubic feet.*

* Other details of the districts quoted will be found among the tables, &c., in Division II.

MANUAL OF HYDROLOGY.

DIVISION III.

TIDES OF THE SEA, ESTUARIES,

AND

TIDAL RIVERS,

WITH

TABLES OF DOCKS,

&c., &c.

DIVISION III.—TIDES, ESTUARIES AND TIDAL RIVERS.

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DIVISION III.

TIDES, ESTUARIES, AND TIDAL RIVERS.

ON THE TIDAL WAVE.

THE Civil Engineer ought to be intimately acquainted with the phenomena and theory of tides and waves, and of their practical development under the varying conditions met with in the ever-changing aspect of coasts, rivers and harbours. The effect of tidal action for long past ages has to be distinguished from what has been created by original geological structure; the form and material of coasts and estuaries being frequently rather a cause of obstructions, or defects, than an effect. Legal questions also arise, and possible results of artificial works are suggested, to combat and understand which it is frequently of the most vital importance to be able to study existing examples and effect of previous engineering operations. This is the more necessary, because in the case of tidal works, as in river alterations, and in the occurrence of accidents or damages by floods, events are often referred to the wrong cause, or their share of contribution towards a new state of things is obscure or remote.

If the reader of these notes should desire to make himself master of the subject as far as theory can carry him, the most elaborate and invaluable treatise on Tides and Waves, by the learned Astronomer-Royal, and the series of papers by Lubbock and Whewell in the Philosophical Transactions, will afford all that can be desired of theoretical computation and practical deduction. We cannot attempt to follow these treatises in detail, but, to shew the enormous practical effect of depth and freedom of motion in length of waves, we quote the following table of the velocity of free or solitary waves, with their relative length and velocity, and depth of water required to produce such velocity: this table is computed from the mathematical formula for a simple wave in a non-elastic fluid. (*See Airy on Tides and Waves, Encyclo. Metrop.*, p. 291.)

Depth of Water in feet.	Length of Wave in feet.							
	1	10	100	1,000	10,000	100,000	1,000,000	10,000,000
	Corresponding velocity in feet per second.							
1	2.26	5.34	5.67	5.67	5.67	5.67	5.67	5.67
10	2.26	7.15	16.88	17.92	17.93	17.93	17.93	17.93
100	2.26	7.15	22.62	53.39	56.67	56.71	56.71	56.71
1,000	2.26	7.15	22.62	71.54	168.83	179.21	179.33	179.33
10,000	2.26	7.15	22.62	71.54	226.24	533.90	566.72	567.10
100,000	2.26	7.15	22.62	71.54	226.24	715.43	1688.3	1792.1

Professor Airy proceeds to shew from this Table that—

"1st. When the length of the wave is not greater than the depth of water the velocity depends (sensibly) only on its length, and is proportionate to the square root of its length.

"2nd. When the length of the wave is not less than one thousand times the depth of the water, the velocity of the wave depends (sensibly) only on the depth, and is proportionate to the square root of the depth. It is in fact the same as the velocity which a free body would acquire by falling from rest through a height equal to half the depth of water.

"3rd. For intermediate proportion of length of wave and depth of water, the velocity can only be got by the general equation.

"The wave originally produced by the action of the sun or moon, may be called the *Free Tide Wave.* The semi-diurnal tide wave is of this character, and may be taken to have a period of 12 hours 24 minutes; now, by the foregoing table we see that a wave exceeding 1,000,000 feet will travel with a velocity sensibly independent of its length; on this principle, therefore, is calculated the following

TABLE FOR THE SEMI-DIURNAL FREE TIDE WAVE.

Depth of Water, in feet.	Velocity of free tide wave per second, in feet.	Length of free tide wave, in miles.	Space described by free tide wave per hour, in miles.
1	5.67	47.94	3.86
4	11.34	95.89	7.73
10	17.93	151.62	12.28
20	25.36	214.42	17.29
40	35.87	303.24	24.46
60	43.93	371.38	29.95
80	50.72	428.88	34.58
100	56.71	479.46	38.66
200	80.20	678.05	54.68
400	113.42	958.91	77.33
600	138.91	1174.4	94.71
800	160.40	1356.1	109.36
1,000	179.33	1516.2	122.27
2,000	253.61	2144.2	172.92
3,000	310.62	2626.1	211.78
4,000	358.67	3032.4	244.55
5,000	401.00	3390.2	273.41
6,000	439.27	3713.8	299.50
7,000	474.47	4011.4	323.50
8,000	507.23	4288.3	345.84
9,000	538.00	4548.5	366.82
10,000	567.70	4794.6	386.66
20,000	802.00	6780.5	546.82
30,000	982.25	8304.4	669.71
40,000	1134.2	9589.1	773.32
50,000	1268.1	10721.	864.59
60,000	1389.1	11744.	947.11

"The diurnal and other tidal waves, so far as they are free, may be all considered as travelling with the same velocity, but the column of lengths of the wave must be doubled for the diurnal wave."

In addition, however, to the *free tide wave*, which is that originally produced by the sun and moon, but not affected by them in the velocity of its propagation, we have that which Professor Airy calls the *forced*

tide wave, produced by the immediate action of the sun and moon, with its highest or lowest point always at a determinate distance in that place (in the supposed canal) at which the disturbing forces vanish.

The following contains the substance of the general results of the inquiries made by the Committee of the British Association, in 1837, in a report for which we are indebted to Mr. John Scott Russell, who claimed to have discovered the existence of a GREAT PRIMARY WAVE of fluid, differing in its origin, its phenomena, and its laws, from the undulatory and oscillatory waves. The report stated—

"2. That the velocity of this wave in channels of uniform depth is independent of the breadth of the fluid, and equal to the velocity acquired by a heavy body falling freely by gravity through a height equal to half the depth of the fluid, reckoned from the top of the wave to the bottom of the channel.

"3. That the velocity of this primary wave is not affected by the velocity of impulse with which the wave has been originally generated, neither do its form or velocity appear to be derived in any way from the form of the generating body.

"4. This wave has been found to differ from every other species of wave in the motion which is given to the individual particles of the fluid through which the wave is propagated. By the transit of the wave the particles of the fluid are raised from their places, transferred forwards in the direction of the motion of the wave, and permanently deposited at rest in a new place at a considerable distance from their original position. There is no retrogradation, no oscillation; the motion is all in the same direction, and the extent of the transference is equal throughout the whole depth. Hence this wave may be descriptively designated THE GREAT PRIMARY WAVE OF TRANSLATION. The motion of translation commences when the anterior surface of the wave is vertically over a given series of particles, it increases in velocity until the crest of the wave has come to be vertically above them, and from this moment the motion of translation is retarded, and the particles are left in a condition of perfect rest, at the instant when the posterior surface of the wave has terminated its transit through the vertical plane in which they lie. This phenomenon has been verified up to depths of five feet.

"5. That the elementary form of the wave is cycloidal; when the height of the wave is small in proportion to its length, the curve is the prolate cycloid, and as the height of the wave increases the form approaches that of the common cycloid, becoming more and more cusped until at last it becomes exactly that of the common cycloid with a cusped summit; and if by any means the height be increased beyond this, the curve becomes the curtate cycloid, the summit assumes a form of unstable equilibrium, the summit totters, and falling over on one side forms a crested wave, or breaking surge.

The report stated—

"That in the rectangular channel the velocity is that of gravity due to half the depth. In the sloping or triangular channel the velocity is that due to one-third of the greatest depth. In a parabolic channel the velocity is that due to three-eighths or three-tenths of the greatest depth, according as the channel is convex or concave; and finally that the velocity of the great primary wave of translation of a fluid is that due to gravity acting through a height equal to the depth of the centre of gravity of the transverse section of the channel below the surface of the fluid.

"7. The height of a wave may be indefinitely increased by propagation into a channel which becomes narrower in the form of a wedge, the increased height being nearly in the inverse ratio of the square root of the breadth.

"8. If waves be propagated in a channel whose depth diminishes uniformly, the waves will break when their height above the surface of the level fluid becomes equal to the depth at the bottom below the surface.

"9. The great waves of translation are reflected from surfaces at right angles to the direction of their motion without suffering any change but that of direction.

"10. The great primary waves of translation cross each other without change of any kind, in the same manner as the small oscillations produced on the surface of a pool by a falling stone.

"11. The WAVES OF THE SEA are not of the first order—they belong to the *second or oscillatory order* of waves—they are partial displacements at the surface, which do not extend to considerable depths, and are therefore totally different in character from the great waves of translation, in which the motion of displacement of the particles is uniform to the greatest depth. The displacement of the particles of the fluid in the waves of the sea is greatest at the surface, and diminishes rapidly. There are generally on the surface of the sea, several co-existent classes of oscillations of varying direction and magnitude, which by their union give the surface an appearance of irregularity which does not exist in nature.

"12. When waves of the sea approach a shore, or come into shallow water, they become waves of translation, and obeying the laws already mentioned, always break when the depth of the water is not greater than their height above the level.

"17. A tidal bore is formed when the water is so shallow at low water that the first waves of flood tide move with a velocity so much less than that due to the succeeding part of the tidal wave, as to be overtaken by the subsequent waves, or wherever the tide rises so rapidly, and the water on the shore or in the river is so shallow that the height of the first wave of the tide is greater than the depth of the fluid at that place. Hence in deep water vessels are safe from the waves of rivers, which injure those on the shore.

"18. The identity of the tide wave, and of the great wave of translation, shew the nature of certain variations in the establishment of ports situated on tidal rivers. Any change in the depth of the rivers produces a corresponding change on the interval between the moon's transit and the high water immediately succeeding. It appears from the observations in this report, that the mean time of high water has been rendered 37 minutes earlier than formerly by deepening a portion of about 12 miles in the channel of a tidal river, so that a tide wave which formerly travelled at the rate of 10 miles an hour, now travels at the rate of nearly 15 miles an hour.

"19. It also appears that a large wave or a wave of high water of spring tides travels faster than a wave of high water of neap tides, shewing that there is a variation on the establishment, or on the interval between the moon's transit and the succeeding high water, due to the depth of the fluid at high water, and which should, of course, enter as an element into the calculation of tide tables for an inland port derived from those of a port on the sea shore. The variation of the interval will vary with the square root of mean depth of the channel at high water."

The report suggests that "these results give us principles, 1st, for the construction of canals; 2nd, for the navigation of canals; 3rd, for the improvement of tidal rivers; 4th, for the navigation of tidal rivers; 5th, for the improvement of tide tables.

Considerable light will be thrown upon these propositions, by careful examination of the examples of river and estuary tides, given in a subsequent part of this division of our treatise.

The following experiments were made for the purpose of determining

whether the velocity of the so called great primary wave were not affected by the initial velocity given to the fluid at its generation by the moving body. The velocity of genesis, or of the vessel by whose displacement the elevation of fluid was produced, is given in miles per hour, and the time occupied by the wave in describing 700 feet is given in seconds.

	Velocity of genesis.	Space described by the wave.	Interval of time.
(1.)	5 miles an hour	700 feet	62. seconds
(2.)	3 ,,	700 ,,	61. ,,
(3.)	10 ,,	700 ,,	61. ,,
(4.)	7 ,,	700 ,,	62. ,,
(5.)	7 ,,	700 ,,	62. ,,
(6.)	4 ,,	700 ,,	61.5 ,,

"From this it is manifest that the velocity of the propagation of the wave does not vary with the velocity of its genesis.

"To determine whether the height of the wave produced any variation in its velocity, the following experiments were made :—

	Height of the wave above the level.	Space described.	Interval.
(7.)	6.0 inches	700 feet	61.50 seconds
(8.)	5.0 ,,	700 ,,	61.75 ,,
(9.)	3.5 ,,	700 ,,	62.50 ,,
(10.)	2.0 ,,	700 ,,	63.50 ,,

"It appears from these examples that, in a given reservoir of fluid, the higher wave moves more rapidly than the lower; and it was afterwards found that the increase in height was equivalent, in its effect on the velocity, to an equal addition to the depth of the fluid in the reservoir.

"To determine whether the depth of the fluid affected the velocity of the wave, the following experiments were made in the same channel filled to different depths :—

	Depth of fluid.	Space described.	Velocity of wave.
(11.)	5.6 feet	486 feet	9.594 miles an hour
(12.)	3.4 ,,	150 ,,	7.086 ,,

"The former of these observations is exclusive of the height of the wave, and adding six inches to the depth of the fluid in this case, the height of the wave being already added to the depth in (12), we find that the velocities are nearly proportional to the square roots of the depths, and are nearly equal to the velocities that would be acquired by a heavy body in falling through heights equal to half the depth of the fluid.

"In the last case the channel was rectangular, and consequently the depth of the fluid was uniform across the whole depth of the channel; it was next of importance to ascertain what law held in those cases where the depth diminished towards the edges of the channel. For this purpose two channels were selected having the greatest depths in their middle, and diminishing towards the sides. The following are the results :—

	Greatest depth in the middle of the channel.	Space described.	Velocity of wave.
(13.)	5.5 feet	1000 feet	7.84 miles an hour.
(14.)	4.0 ,,	820 ,,	6.09 ,,

"In these instances the diminished depth at the sides has diminished the velocity of the wave below that due to the greatest depth in a ratio in the first example nearly of 9.5 to 7.8, and in the second of 7. to 6. See Experiments (11) and (12).

"The following three experiments are instructive as having been made on channels in which the maximum depth was nearly the same in all; but in (15) the depth remained constant to the side which was vertical, in (16) the sides had a slope of nearly 20°, and in (17) a slope of nearly 40°, so as to diminish the depth towards the sides.

	Maximum depth.	Form of channel.	Space described.	Velocity.
(15.)	5.6 feet	Rectangular	486 feet	9.59 miles
(16.)	5.5 ,,	Slope of 20°	2,038 ,,	8.83 ,,
(17.)	5.5 ,,	Slope of 40°	1,000 ,,	7.84 ,,

"From these it is manifest that the depth of the channel, while it modifies the depth of the fluid, affects the velocity of the wave. It was not found that the breadth of the channel produced any similar effect.

The report contained experiments made on the river Clyde between the Bromielaw and 20 miles below Port Glasgow; they are described in the following table, and will be better understood by referring to the plan and section of this river, plate XI.

			Diff. of level at H.W.		Diff. at L.W.	H.W. time.	
Station	1	Glasgow	10.1 inches.	Higher than at Port Glasgow.	33 inches.	83 mins.	Later than at Port Glasgow.
Station	2		9.1 inches.		31 inches.	76 mins.	
Station	3	Clyde Bank	7.0 inches.		27 inches.	61 mins.	
Station	4		6.1 inches.		25 inches.	43 mins.	
Station	5	Bowling	5.2 inches.		12 inches.	24 mins.	
Station	6		2.2 inches.		5 inches.	6 mins.	
Station	7	Port Glasg.	0.0 inches.		0 inches.	0 mins.	

From this it appears that the wave of high water travelled

From	9	to	8	in 6 min. ...	14 miles	80 miles an hour.
From	8	to	7	in 9 min. ...	6 miles	
From	7	to	6	in 6 min. ...	3.75 miles	20 miles an hour.
From	6	to	5	in 18 min. ...	4.25 miles	
From	5	to	4	in 19 min. ...	2.5 miles	8.1 miles an hour.
From	4	to	3	in 18 min. ...	2.5 miles	
From	3	to	2	in 15 min. ...	2.75 miles	15 miles an hour.
From	2	to	1	in 7 min. ...	2.75 miles	

"These results shew that in the deep water being between 40 and 60 fathoms, or between 240 and 360 feet deep, the wave travels at the enormous rate of 80 miles an hour; that on reaching water from 20 to 30 feet deep, the velocity is diminished to 20 miles an hour; and from 5 to 3 where the river is wide, shelving, and shallow, the velocity of the tide wave is retarded to 8 miles an hour; while on ascending further up, where the bank is nearly upright, and the contracted width gives an increase of mean depth, the velocity has a corresponding increase to 15 miles an hour. It will appear, on consulting plate XI., that the average depth of the river, from 1 to 3, was 15 feet. From 3 to 5 the river is wide and shallow, spreading over extensive banks, where there are not 2 feet of water, for which we may take a third part of the greatest as a mean depth, or about 5 feet. In the division from 5 to 7, both depth and breadth increase very rapidly, and 25 feet may be taken as the mean depth. From 7 to 9 the depth became very great. The following is a condensed table of the results of the above experiments.

Velocities of the tide-wave as observed.	Mean depth.	Velocity due to depth.
80 miles an hour.	240—360 feet.	60—80 miles.
20 miles an hour.	25 feet.	19.3 miles.
8.1 miles an hour.	5 feet.	8.6 miles.
15 miles an hour.	15 feet.	14.9 miles.

Mr. Scott Russell's experiments were originated by his investigations into the fact of light canal-boats requiring less proportionate power for hauling them at high speeds than at the lower rates previously adopted. This was a strong exemplification of the free wave which will travel along a canal of a given depth, k, at the velocity defined by $v^2 = g\,k$; while this wave is constantly moving forward at a considerable speed by the action of a moving vessel, the *forced wave* is also produced, which is immediately created by and follows the speed of the vessel itself. If, then, the vessel moves more slowly than the *free wave*, the forced wave precedes the centre of the moving body, and the power necessary to keep up speed is great in proportion to the velocity attained. If, on the other hand, the vessel moves *more* rapidly than the *free wave*, the vessel is kept somewhat in advance of the *forced wave*, and the power required for maintaining the speed of the vessel is less than in the former case. But if the vessel moves with a velocity equal to, or slightly exceeding that of the *free wave*, then it is carried along on the top of the wave, and of course in advance of the *forced wave*, and the power required is less in proportion than at lower speeds, and in some cases absolutely less. (See Mr. Scott Russell's paper, in Edinburgh Trans. vol. xiv.)

The remaining experiments have not much practical bearing upon the objects of this treatise; we have abstracted the essential parts of the Committee's Report to the British Association; for the subject is one which had never been previously treated in a comprehensive way. The results are highly instructive to the Civil Engineer, when dealing with tidal rivers and canals, especially in experimental investigations, and in the application of theory to practical designs. This subject may be pursued by consulting the tables of tidal observations for the various rivers and estuaries at the sequel of this division with the plates, more especially those relating to the Clyde, Avon, Severn, and Seine.

Professor Airy regards the great primary wave as simply the solitary wave in its earliest and simplest condition, in which a particle is actually moved a certain distance by the wave, and then remains at rest in a new position; this wave, he observes. by mathematical reasoning, may travel without any force to maintain its motion provided it be long in proportion to the depth of the fluid, and that its velocity be $\sqrt{g\,k}$; k being the depth, and g the force of gravity in feet per second. $\frac{}{2}$

As to ordinary waves, Mr. Russell's experiments shew that a wave always breaks when its elevation above the general level becomes equal to the depth of water; this fact is strikingly evident in the breaking of surf and in the bore; as the friction on the bottom shortens the wave in proportion to its depth, it topples over. In a similar manner the effect is produced when the wave is urged on by wind in open sea, until its height becomes greater than gravity will permit the wave to stand.

It is the same law of friction interfering with the free action of a wave, that renders the effect of tides, and the currents consequent upon them, so different in the varying conditions of rivers and estuaries, when, in addition to the effect of the narrowing sides, we have the general fact that the elevation of the tidal wave has a sensible proportion to the depth of water in which it is generated.

TIDES OF THE IRISH SEA.

As an excellent and accurate example of tidal action in seas and estuaries, we give the following abstract from a paper in the "Philosophical Transactions" for 1847, being Observations on the Tides of the Irish Sea, and upon the great similarity of Tidal Phenomena of the

Irish and English Channels, by the late Captain F. W. Beechey, R.N., F.R.S. The facts developed by the surveys of this lamented officer, assisted by the present hydrographer, Captain Washington, and other most able marine surveyors, afford complete formulæ for the laws which govern tidal flow and currents in confined seas.

"The observations have shewn that, notwithstanding the variety of times of high water throughout the channel, the turn of the stream is *simultaneous*; that the northern and southern streams in both channels commence and end in all parts (practically speaking) *at the same time*, and that time happens to correspond with the time of *high and low water* on the shore at *Morecambe Bay;* an estuary rendered remarkable as being the point where the opposite tides, coming round the extremities of Ireland, finally meet. So that it is necessary only to know the times of high and low water at Morecambe Bay to determine the hour when the stream of either tide will commence or terminate.

"The chart of curves or lines of *direction of the stream*, plate II., will shew at once the effect of the tide upon a vessel, wherever she may be placed in the channel, and especially direct her where, with a beating wind, she will be benefited by standing in shore or otherwise; and taken in connection with the very valuable series of observations which were carried round Ireland by the Ordnance at the suggestion of Professor Airy, we are made acquainted with several curious facts: first, that whilst it is high water at one end of the channel, it is low water at the other; that the same stream makes both high and lower water at the same time; that there are two spots in the channel, in one of which the stream runs with considerable velocity without the water either rising or falling, and in the other, that the water rises and falls from sixteen to twenty feet without having any visible horizontal motion of its surface; and that during the first half of the flowing, and last half of the ebbing tide-wave, the stream in the south channel runs in a contrary direction to the wave, and goes up an ascent of about one foot in 4½ miles.

"Plate II. shews the lines of direction of the stream with the rate of the tide at its greatest velocity on the day of syzygy, all being reduced to the same standard.

"An inspection of the plate will shew that the tide enters the Irish Sea by two channels; of which Carnsore Point and Pembroke are the limits of the southern one, and Rathlin and the Mull of Kintire the boundaries of the northern.

"The stream in the southern channel (as before stated) has been ascertained to move *simultaneously in one vast current throughout;* running six hours nearly each way, at an average rate of from two to three knots per hour at the height of the springs, increasing to four knots and upwards near the banks and at the pitch of the headlands; its *times of slack water* corresponding sufficiently near for all practical purposes with *the times of high and low water for the day at Morecambe Bay*, or more correctly *at Fleetwood*, which is twelve minutes earlier than Liverpool.

"The *central portion* of the stream of *flood* or *ingoing stream*, runs nearly in a line from a point midway between the Tuskar and the Bishops, to one six miles due west of Holyhead; beyond which it begins to expand eastward and westward, but its main body preserves its direction straight forward for the Calf of Man, which it passes to the eastward with increased velocity as far as Langness Point, and then at a more moderate rate on towards Maughold Head. Here it is arrested by the flood or southern stream from the north channel coming round the Point of Ayre, and is first swayed round to the eastward by it, and then goes on with it at an easy rate direct for Morecambe Bay.

"The *outer portions* of the stream are necessarily deflected from the course of the great body of the water by the impediments of banks on the Irish side of the Channel, and by the tortuous form of the coast on the Welsh. The eastern portion passing Linney Head rushes with great rapidity between the Smalls, Grassholm, and Milford Haven, towards the Bishops, which it passes at a rate of between four and five knots; sets sharply round those rocks in an E.N.E. direction, right over the Bass bank, and into Cardigan Bay; makes the circuit of that bay; and set out again towards Bardsey at the other extremity of it; then sweeping to the N. by W. past the island and through the sound, it gradually takes the course of the shore, round Carnarvon Bay, filling the Menai Strait as far as Bangor; but the stream still continuing outside towards the South Stack, which it rounds, setting towards the Skerries at a rate of upwards of four knots; and finally, turns sharply round those rocks for Liverpool and Morecambe Bay; completing in its way the high water in the Menai, and filling the Dee, Mersey, and Ribble.

"The *western* portion of the stream, after passing the Saltee, runs nearly in the direction of the Tuskar, sets sharply round it, and then takes a N.E. ½ N. direction, setting fair along the coast, but over the banks skirting the shore. Abreast of the Arklow is situated that remarkable spot in the Irish Channel, where *the tide neither rises nor falls*. The stream, notwithstanding, sweeps past it at the rate of four knots at the springs, and reaches the parallel of Wicklow Head. Here it encounters an extensive bank recently known; and whilst the outer portion takes the circuit of the bank, the inner sweeps over it, occasioning an overfall and strong rippling all round the edge, by which the bank may generally be discovered; beyond this point the streams unite and flow on towards Howth and Lambay, growing gradually weaker as they proceed, until they ultimately expend themselves in a large space of still water situated between the Isle of Man and Carlingford, where occurs the phenomenon of the water rising and falling without having any perceptible stream. This space of still water is marked by a bottom of blue mud.

"In the north channel the stream enters between the Mull of Kintire and Rathlin *simultaneously* with that passing the Tuskar into the southern channel, but flows in the contrary direction. It runs at the rate of three knots at the springs, increasing to five knots near the Mull, and to four near Torr Head on the opposite side of the channel. The eastern branch of this stream turns round the Mull towards Ailsa and the Clyde. a portion passing round Sanda up Kilbrannin Sound and Loch Fyne.

"The *main body* sweeps to S. by E., taking nearly the general direction of the channel, but pressing more heavily on the Wigtownshire coast; off which it has scooped out a remarkable ditch, upwards of twenty miles long by about a mile only in width, in which the depth is from 400 to 600 feet greater than that of the general level of the bottom about it. Near the Mull of Galloway the stream increases in velocity to five knots, the eastern portion turns sharply round the promontory towards the Solway, and splits off St. Bee's Head; one portion running up the Solway, and the other towards Morecambe Bay.

"The *central portion* from a midway between the Mull of Galloway and the Copeland Islands, presses on towards the northern half of the Isle of Man, and while one portion of it flows toward the Point of Ayre, the other makes for Contrary Head, and is there turned back at a right angle nearly to its early course. Passing Jurby it reunites with the other portion of the stream, and they jointly rush with a rapidity of from four to five knots round the Point of Ayre, and directly across all the banks

lying off there, and catching up the stream from the south channel off Maughold Head, they hurry on together towards that great point of union, Morecambe Bay. This Bay, the grand receptacle of the streams from both channels, is notorious for its huge banks of sands heaped up in terrible array against the mariner unacquainted with its locality, and also remarkable for a deep channel scoured out by the stream, and known as the Lune Deep, which, to the wary navigator, is the great hidden beacon of his safety, and serves him, alike in fog or in sunshine, as a guide to his position, and to a harbour of safety in case of need.

"We have now only to speak of the *western limit* of the stream, which we left off Torr Head running at a rate of four knots off the pitch of the point. Hence it strikes directly towards the Maidens, boiling over the Highlander and Russell rocks, and other reefs in the vicinity of that dangerous group; and takes the direction of the coast again from Muck Island to Black Head, at the entrance of the Lough of Belfast, which it fills.

"The portion of the stream which sets up the Lough splits again off Grey Point; one portion flowing up towards Garmoyle, while the other bends back along the shore of Bangor, Grimsport and Orlock, and blends with the general stream which has come on from the Maidens and Blackhead, and passes with it through the sounds of the Copeland Islands. Hence it proceeds along the coast, brushes the South rock, and runs on towards St. John's Point; off which, the stream, like that coming from the southward, expends itself in a large space of still water, which remains undisturbed although pressed upon by streams from various quarters.

"Such is a general description of the streams in both channels which attend the *flowing of the water*, or which, for the purpose of distinction, we may designate the *ingoing stream*.

"The ebbing or *outgoing* streams do not materially differ from the reverse of these, except that in the southern channel they press rather more over towards the Irish coast.

"This is a general idea of the course of the streams throughout the Irish Sea, represented in plate II.; but besides these there are (as usual) at all the points and headlands, when abrupt, counter streams or eddies beginning at about two hours after the offing stream, increasing with the strength of the tide, and occasioning races and overfalls at the places marked on the chart. In the direction of the offing stream there is as little variation of the current at the different hours of tide as will be met with in any sea of similar extent, and indeed it is only with the slackening of the tide that the variations occur, which happens from about forty minutes before to about forty minutes after high or low water at Morecambe Bay.

During the time these observations on the stream were in progress, others were made upon the *rise* and *fall of the water* at several stations in the channel, and wherever practical at places in the offing. By combining these observations with the range of tide on the coast of Ireland, published in Professor Whewell's admirable paper on the Tides in the 'Philosophical Transactions' for 1836, Part II., and with observations made by Captains Robinson, Denham, Frazer, Sherringham, Williams, &c., Captain Beechey constructed a chart of lines of equal range of tide, plate I. The seaman may ascertain by a simple inspection of this chart, wherever he may be placed in the channel, the amount of spring range to which he has to adapt his soundings; the curved lines denote the range of tide at the places over which they pass, on a day when a spring tide at Liverpool rises thirty feet.

"All the tides of the Irish Sea partake of the nature of river tides in

having their ebb longer than their flood, except those of Tuskar and Holyhead, which are the reverse. The following table of the times of ebb and flow was compiled from the mean of many observations; the cases are given in the order in which the places occur.

DURATION OF TIDE.

	Rising. h.	m.		Falling. h.	m.
Tuskar	6	27	...	6	8
Bardsey	5	24	...	6	52
Holyhead	6	18	...	6	0
Peel, Isle of Man	6	0	...	6	15
Ramsay, Isle of Man	5	48	...	6	35
Fleetwood	5	46	...	6	39

"The change at Holyhead is remarkable, and if we follow the durations up to Ramsay, we shall see that Peel also, an intermediate station, is affected. The cause of this may possibly be connected with the effort of the water to maintain its level; for in projecting the curve of the wave on paper, this peculiarity, in connection with the very short flood of Bardsey, has the effect of reducing the curve from what it would assume, were Holyhead similarly influenced with other places."

In the Irish Sea it was found that the place of the *water at the half-tide interval* did not correspond with that of a mark at *the half range of the wave*, but that it was always below it, shewing that the upper half of the wave rose and fell more rapidly than the lower. It was also found that the curve of the Irish Sea tide did not correspond with that of the Bristol Channel tide; that neither followed the law of the sines or corresponding areas of tidal intervals.

"In connection with the range of tide is that of the apparent mean elevation of the water. All the observations confirm the remark of Professor Airy (Phil. Trans. 1845, Part I. p. 31), viz., that this mean level is higher at the springs than at the neaps. The mean place of the water, however, for an entire lunation, during the summer months at least, is tolerably constant, and affords a fair standard to which the reductions used in our nautical surveys may be referred in the event of the gauge being removed by which the observations were made; annexed is the result of observations made at Holyhead during nearly four entire years.

APPARENT MEAN PLACE OF THE WATER AT HOLYHEAD.

Month.	1838. ft.	in.	1839. ft.	in.	1846. ft.	in.	1847. ft.	in.	Mean of Months. ft.	in.	
January ...	11	$3\frac{1}{4}$	10	6	.....		10	7	10	$9\frac{1}{2}$	
February ...	10	$6\frac{1}{2}$	10	3	.....		9	10	10	$2\frac{1}{4}$	
March	10	1	10	2	.....		10	4	10	$2\frac{1}{2}$	
April	10	1	9	10	.....		9	11	9	$11\frac{1}{2}$	Summer months.
May	10	2	9	9	10	$0\frac{1}{2}$	9	$11\frac{3}{4}$	9	$11\frac{3}{4}$	
June.....	.....		10	1	10	4	9	$11\frac{3}{4}$	10	$1\frac{1}{2}$	
July	10	1	10	$1\frac{1}{2}$	10	$1\frac{3}{4}$	9	$10\frac{3}{4}$	10	$0\frac{3}{4}$	
August	10	6	9	10	10	1	9	$10\frac{3}{4}$	10	$0\frac{3}{4}$	
September .	10	4	10	7	11	1	10	$3\frac{1}{4}$	10	$6\frac{3}{4}$	
October	10	$6\frac{3}{4}$	10	$3\frac{1}{2}$	10	8	10	10	10	7	
November ..	10	7	10	$2\frac{1}{2}$	10	$7\frac{3}{4}$	10	$9\frac{3}{4}$	10	$6\frac{3}{4}$	
December...	10	7	11	2	10	6	10	11	10	$9\frac{1}{2}$	
Mean of the year	10	5	10	$2\frac{3}{4}$	10	$5\frac{1}{2}$	10	$3\frac{1}{4}$	10	$3\frac{3}{6}$	

Captain Beechey proceeds to trace the course of the stream from Pembroke to the Land's End; to connect the tides of the Irish Sea with those of the Bristol and English Channels, and finally with those of the offing. The following observations will be explained by reference to plates III. and IV., which shew the tidal streams in the English and Irish Channels respectively.

"It seemed evident that the water was influenced by forces acting in opposition nearly to each other, and that there was a tide in the offing whose streams of ebb and flood did not correspond with those of the channels. By applying this idea first to the English Channel, the observations responded to it; and carrying it to the offing of the Irish Sea, and considering that channel as comprising the Bristol Channel within its limits, as the English Channel does the Gulf of St. Malo, the idea was confirmed so far as the observations themselves extended. This offing stream appears to be of great extent, setting to the north and south along the coast of Biscay and the British Isles, running six hours nearly each way, and exercising an influence with more or less effect over all the waters of the channels and estuaries it passes in its progress, diverting their courses, and in some cases, when the streams oppose, wholly overpowering or reversing their direction. From the connection of the observations of the Irish Sea with those of the Bristol Channel, it is clear that the whole of the ebb or outgoing stream of the eastern half of the Irish Channel runs into the Bristol Channel, and forms the flood or ingoing tide of the northern half of that great estuary; and *vice versâ* the ebb or outgoing stream from the northern half of the British Channel, forms the flood of the Irish Sea, each tide passing to and fro with great rapidity round St. Govan's Head. The centre and southern half of the Bristol Channel receive their waters from the offing and the English Channel, the coast stream bringing the waters up from the Land's End and the English Channel, as the stream on the northern half did those of the Irish Channel, and *vice versâ*.

"The great offing stream at the entrance of the English Channel extends its influence as far up as Cape La Hague, beyond which, owing perhaps to the sudden contraction which there occurs in the Channel, the stream suffers no interruption, but, as in the Irish Sea, passes up and down the Channel six hours nearly each way as far as a line joining Dungeness and Cape Grisnez, the apparent *virtual head* of the tidal channel. Here the influence of the North Sea stream begins to be felt, and here, as in the Irish Channel, again *the time of high and low water at the virtual head of the tide regulates the turn of the up and down stream along the whole Channel* as far as the contraction. Beyond this the offing stream being governed by its own high water, and that occurring at about six hours earlier than that at the head of the Channel, the offing stream either butts against the returning streams from the channels, or withdrawing its water, solicits their streams and thus alters their course, making them for the most part set across the Channel in curves more or less bent as the spot is more or less removed from the offing; so that there seems to be but one hour's tide each way that passes clean down the Channel from Beachy Head to Scilly, and round the Land's End to Bristol. The outgoing stream from Beachy Head encounters the ingoing stream of the offing tide somewhere about the Start Point, and both are turned down into the great Gulf of St. Malo, which seems to receive the accumulated waters of these opposite tides.

"Whether or not this influx is instrumental in raising the water here to the extraordinary height of forty-seven feet perpendicular range at springs, or whether it be owing to its form and position as regards the advancing tide wave, is a problem; but it is a coincidence that cannot

escape observation, that this spot like the Bristol Channel, is the concentration of streams from opposite directions; that it has its waters raised to the same extraordinary elevation nearly to a foot, and that its time of high water is nearly the same.

"On the change of tide, this great bay, like the Bristol Channel, as it received so it returns its waters in opposite directions, the tide splitting somewhere between Alderney and the Start; but here especially, as also in a similar locality in the Irish Channel, we are in want of observations.

"In tracing these streams, it was impossible not to be impressed with the many coincidences which assimilate the tidal phenomena of the two channels, so much so as to render it probable that they are subjected to precisely the same laws.

"Considering the Irish Channel to extend from a line adjoining the Land's End and Cape Clear to the end of the tidal flow, which is either at Morecambe Bay or Peel, in the Isle of Man; and the English Channel as reaching from a line connecting Ushant with the Land's End, to the end of its tidal flow, or to Dungeness, we shall then see that the English Channel, from its outer limit to the end of its tidal stream, is 262 geographical miles, and that the Irish Channel, from its western limit to the end of its tidal stream, is nearly the same; being about 265 geographical miles. In both channels the stream enters from the south-west, and flows up until stopped by a counter stream. In both channels there is a contraction of the strait almost midway, by the promontories of Cape La Hogue in one instance, and St. David's Head in the other, and at very nearly the same distances from the entrance. This contraction is, in both cases, the commencement of the regular stream, which flows six hours nearly each way, the *turn of the stream throughout coinciding with the times of high and low water at the virtual head of the channel*, situated in both cases about 145 miles above the contraction, and that time being very nearly the same, viz., 10h. 50m. at full and change; below this contraction, away from the land, the stream in both cases varies its direction nearly every hour, according to the force exerted upon it by the opposing offing stream.

"In both cases, between the contraction and the southern horn of the channel, there is situated a deep estuary, the Bristol Channel and the Bay of St. Malo, in which the times of high water coincide, and where, in both cases, the opposing streams meeting in the channel pour their waters into these gulfs, and where the tides in both places rise to the extraordinary elevation of forty-seven feet at the syzygies. From the Land's End to the meeting of these streams in the Bristol Channel is seventy-five miles, and from Brest to the meeting of the streams off Guernsey the same. A still further coincidence is apparent between the phenomena of these channels. In one, at a place called Courtown, a little above the contraction of the strait, and at 150 miles from Cape Clear (its entrance), there is scarcely any rise or fall of the water; and in the other channel (about Swanage), situated also a little above the contraction of the strait, and just 150 miles from the Land's End, there is only five feet rise of the water at a spring range. In both cases these points of small range of tide are situated on the opposite side of the channel to that of the high elevation above mentioned, and in both cases these spots are the node of the tide-wave (on either side of which the times of high and low water are reversed). And again we trace a similarity in an increased rise of the water on the south-east sides of both channels abreast of the virtual head of the tide; at Liverpool in one case, where the range amounts to thirty-two feet, and at Cayeux in the other, where it is thirty-four feet.

"It may also be shewn that the progress of the tide-wave along the

side of the channels opposite the node is not very dissimilar. Reckoning in both cases from the line which we have before drawn, as the outer limits of the channel, we find that in the English Channel, from the line to Cherbourg, opposite the small range of tide—

	Miles per hour.		Miles.
The wave travels...	50	and if complete would be in extent	616
In the Irish Channel, from a similar line to Bardsey, it travels	52		649
From Cherbourg to Havre	32		397
From Bardsey to Holyhead	16		193
From Holyhead to end of tide	78		959
Dieppe to the end of the tide	75		922

These numbers are given roughly, merely for the purpose of shewing the general resemblance in the character and motion of the wave; and it is probable a more judicious selection of positions and numbers would give a still nearer coincidence. Besides which we are somewhat uncertain as to the establishment at our starting-point. As a comparison, however, the numbers run fairly together. In both cases the retardation of the tide-wave about mid-channel, and the great elongation of the wave towards the end of the strait, are remarkable, especially in the Irish Sea.

"Lastly, we may notice a singular coincidence in more respects than one, indeed, between the situation of the node placed by Professor Whewell in the North Sea, and a corresponding point of small range and inversion of tide at the back of Kintire. The node or hinge of the tide in the North Sea is curiously enough situated as nearly as possible at *the same distance from the head of the tide off Dungeness, as the node at or near Swanage* is on the opposite side of it; and the node at Kintire communicated by Captain Robinson, is about the same distance from the meeting of the tide in the Irish Sea as the North Sea node is from the meeting of the waters off Dungeness, and is similarly *situated with respect to the node of Courtown as the North Sea node is with regard to Swanage.*"

TIDES OF THE ENGLISH CHANNEL AND NORTH SEA.

Captain Beechey's paper, in the *Philosophical Transactions*, Part II., for 1851, contains his investigations into the currents and tides of the English Channel and North Sea similar to those on the tides of the Irish Sea. Instead of these channels having a stream turning progressively later as the tide advances up the strait, it was found that the tide turns off the Start on one side of Dover, and the Lynn Deeps on the other side; between these points the tide sets steadily *towards* Dover, while the water is *rising* there; and *away* from Dover in each direction when the tide is *falling* there. This "true channel stream" is about 180 miles in length each way, from the point of union, towards Lynn in one direction, and towards the Start in the other. The point of union of the tides off the straits of Dover oscillates between Beachy Head and the North Foreland, a distance of sixty miles. When the water at Dover begins to fall, the separation takes place off Beachy Head, gradually creeping to the eastward as the fall of tide at Dover continues—at two hours after high water it gets to Hastings, at three hours it arrives at Rye; and when it is low water at Dover the line of separation is between Dunkirk and the North Foreland.

It appears, from the elaborate charts which accompany Captain Beechey's paper, "that, for a period of six hours after high water at Dover

and for five hours before that time, the great stream of the English Channel and North Sea maintains a steady direction from and towards Dover." Between Cromer and the North Foreland, Captain Beechey states that there is not half an hour's retardation in the time of slack water from the time of high water at Dover, while in the establishment there is a difference of five hours; on the other side, the stream, half way between Start Point and Alderney, turns with high water at Dover, although the difference of establishment is also five hours. Off Portland the tide turns nine minutes before high water at Dover; off St. Albans, three minutes before; between the Isle of Wight and Cape Barfleur, fifteen minutes after; and so on. Reasoning on these facts, we find that when it is high water at Dover (which is five hours after high water at Start point) the tide has fallen about thirteen feet off the Start—or there is about fifteen feet actual difference of level in the water surface at the two places, when the current turns at spring tides: taking this difference, we have a fall of one inch per mile of the surface; this is ample for the gravitating power to produce the tidal stream, which appears to vary from 120 to 400 feet per minute.

Plates IV.A and IV.B contain a general view of these facts, with the set of currents and their terminations at one, three, and five hours before and after low water at Dover: the currents of the rising tide are shewn in plate IV.A, and of the falling tide in plate IV.B.

Diagrams of the curves of the Channel tide-wave for every hour of rise and fall are given on the plates; the range is from the mean of the tides on the parallel of the principal stations where the tide was observed. The diagrams give the general inclination of the surfaces of the combined wave on both sides, with the direction of the streams passing along the channel at the moment, marked by arrows on each hour-line: this exhibits the mechanical action of the water, and the intimate connection existing between the wave and the simultaneous turn of the stream.

On examining the surfaces of these waves, we shall see that the directions in which the streams run do not always correspond with the existing slopes of the surfaces, but that during the last half of the tide they are to be traced to the effect of a previous and contrary depression: this is a question of *time*, which is an essential part of the law of gravitation. The maximum rate of the stream is at half-tide when the surface has its least depression, and the stream ceases at the moment of the greatest elevation and depression. The amount and continuance of the inclination governs the rate of the streams, which continues its progress for a length of time, although the surface slope of the wave that produced it may have been reversed. Consequently, from the time of the passage of the wave until the stream finally ceases to flow, the water will be seen to run up an inclined plane, and will continue to do so for nearly as long an interval before it be brought to rest as it did to acquire its momentum; the relative inclinations at the beginning and ending being about the same. The simultaneous reversal of the stream throughout the Strait is therefore the effect of gravitation due to the general slope of the surface, and the law of motion is precisely that of a pendulum.

The maximum velocities of the Channel stream, in reference to the time of high water at Dover, are given on plate IV.A; the period of greatest velocity is always about half tide at Dover. (*See Captain Beechey's Paper—Phil. Trans.*)

LINES OF COTIDAL WAVES.

We have given in some detail the principal features of these accurate surveys of the English and Irish Channels, because they afford strict ex-

amples of what we find practically, and may expect from theory, in the development of the simple tidal wave, with its numerous offshoots or minor vibrations, and the secondary effects produced by Mr. Airy's "forced tidal wave." These great undulations follow the deepest and smoothest channels with their maximum velocity, and are retarded by laws which there is no doubt could be strictly defined, if we had the nature of bottom, and other disturbing forces, as elements in the calculation. It is evident that the primary, or great tidal wave, passes in at each end of the channels with the deepest line of sounding: this produces the alternate overflow and recession of the central volume towards the coasts, while the offing tide, which is described as apparently passing across the entrance of the channels, is nothing more than the same effect of a great succession of waves, following the disturbing or creative cause round the globe, and turning over towards the gradually shoaling bottom on approaching the British Isles, where again the line of least resistance is taken up the channels by the diverging waves. Thus the highest equinoctial tides take place, on the west coast of Ireland and on the south coast of England, three transits after the new and full moon, unless diverted by gales of wind or other extraordinary causes. Along the east coast of England, they take place four transits after the new and full moon. In the river Thames they occur five transits after the same epoch. These differences arise from the cause, that the same tide-wave which produces high water on the west coast of Ireland takes half a day in its progress from thence to the east coast of England, and a whole day before it arrives in the river Thames.

On reference to our remarks on the various rivers and estuaries, of which we have given the phenomena from accurate experiments, we see precisely the same effects produced, although frequently developed to a greater degree by rapid diminution of width and depth, or *vice versâ*; and in tracing the results of both the hydrodynamic and undulatory action of water, we must always recollect that it is a *non-elastic* fluid; so that wherever at a point, in a given channel, there is want of area, we have increased head or oscillation, and as a secondary effect, increased velocity; while on the other hand, where there is cessation of velocity, we have increase of area. So, where the bed and banks are capable of being acted upon (and what are not ?) we find invariably that, unless perfection of regularity exists, there is perfect irregularity; that is to say, for every indentation there is projection—for every depth too great, there is depth too little; for every variation *above* the mean or true velocity, we have a similar falling *below* the mean; a perpetual recurring equilibrium which is attained by velocity or depth, by time or space.

Thus it is the great law of equilibrium which indicates what should be the proportion of artificial hydraulic construction; the more nature is aided in creating such equilibrium, the more rapidly are her powers developed; by deepening, and straightening, and reducing into train any channel or tidal river, we get nature to aid in producing the effect; calling in assistance of a tenfold effort, because it is one developing upon itself, and generating new powers from the combination.

We subjoin remarks from Airy's Treatise in reference to the cotidal lines of the globe, as they have especial relation to the question of depth and its effects.

"In all places where the circumstances of depth, &c., vary much in a small extent of sea, we may consider the alteration in the tides through that extent as following simply the laws of waves on which no force is acting (because the length of the column of water on which the sun or moon acts is too small to allow their attraction sensibly to modify their pressures). Suppose now that in the neighbourhood of any particular

coast, the bottom shelves gradually from deep sea to one comparatively shallow. This would be attended, theoretically, with two consequences. The first is, that the wave would travel more slowly, and therefore the separation of the cotidal lines corresponding to successive hours would be less, or the cotidal lines would appear to be crowded together on the map. The second is, that the magnitude of the tides would be much increased. And these circumstances might be found in places where the change in the depth was not known from observation; for the usual limit of sounding is 200 fathoms, which is probably a small quantity compared with the depth of the ocean. We may then expect that, where the cotidal lines approach closely, the magnitude of the tides will be increased. Now this does occur. A well-marked instance is the Bay of St. George, in South America, in which a close approximation of cotidal lines is accompanied with large tides. It is possible here that the tides may be still further increased by the converging form of the waves.

"Another curious effect of the same cause is the distortion of the lines produced by islands, surrounded by shoals, in the ocean. The shoals prevent the tide-wave from advancing rapidly, and the cotidal line is therefore thrown back; but conceiving the ridge of the wave to be thus bent, it is easy to imagine that after passing the island the two lateral parts of the wave will bend round it till they unite, and will then form a straight front nearly as before coming to the island. The successive cotidal lines will have forms corresponding to the forms of the ridge of this wave at successive times. Of this there are several instances apparently beyond doubt. Thus the 1 o'clock line is thrown back by the Azores; the 11 o'clock line is bent by the Bermudas, and its lateral branches nearly meet; the 10 o'clock line, after having been interrupted, just meets behind New Zealand. A similar effect of the same cause is, the universal dragging of the wave along the shore.

"The velocity of the tide-wave ought, with the assistance of the table, page 206, to give information as to the depth of the sea. Thus in the North Sea, the tide-wave in 9 hours appears to describe somewhat less than 6 degrees of latitude, or on the average about 45 miles per hour: by the table, this would correspond to a depth of 140 feet. We believe that the average depth along the line of deep channel is greater than this, and that at the sides less; and it is probable that the actual velocity is effected by both these. If the tide-wave of the Atlantic were purely derivative, it might be considered as describing 90 degrees of latitude, from the southern 1 o'clock line to the northern 1 o'clock line, in 12 hours, or to move about 520 miles per hour; which would imply a depth of about 18,000 feet or 3½ miles. The reader will have no difficulty in extending similar remarks to other seas; in this, plates I. to V. will assist his inquiries. Curves for spring and neap tides, compiled from the most accurate authorities, are given in plates XVI. and XVII.

ON THE DIURNAL INEQUALITY.

Dr. Whewell's paper, read to the Royal Society in December, 1847, relates chiefly to the tides of the Pacific and the diurnal inequality. He remarks that the cotidal lines in the observations of 1834 and 1835 shewed one feature, viz., their meeting the shore at a very acute angle, and following its flexures with an almost parallel course at a little distance, and that consequently the tide-wave which runs up the middle of a channel is very much in advance of its place at the sides; this is quite in harmony with the laws of fluids, and with the effect of friction and decrease of depth along shore.

Dr. Whewell observes that the diurnal inequality was noticed by

Newton at Plymouth and Bristol, and has been commonly called the difference between the *day* and *night* tide, which is in fact only a temporary distinction.

"It depends upon the moon's declination, and changes to alternate tides when the moon's declination changes from north to south, and *vice versâ*. Its rule is expressed in the following form:—

For moon's N. declination.	{ *Add* to the tide following moon's South transit, *Subtract* from the tide following moon's N. transit,
For moon's S. declination	{ *Subtract* from the tide following moon's S. transit, *Add* to the tide following moon's N. transit,

the quantity added or subtracted being greater as the declination is greater; and the declination being taken for one, two, or three days previous to the tide. According to this law, the inequality is introduced into the Admiralty Tide Tables, and it may be computed for any period by applying Table 39b to the moon's declination.

"This rule of the diurnal tide may, *for some months*, produce the effect of making the afternoon tides greater than the morning tides, or *vice versâ*. Suppose the place to be one where the tide happens (in general terms) soon after the moon's (*south* or *superior*) transit; then, beginning from new moon, the afternoon tide for a fortnight follows the south transit of the moon. Supposing that during this fortnight the moon has north declination; then the diurnal inequality is additive by the rule, and therefore the afternoon tide is, during this fortnight, the highest. Now at the end of a fortnight of north declination, the declination changes to south. But at the end of a fortnight, the afternoon tide begins to be that which follows the *north* or *inferior* transit of the moon; and therefore again, by the second part of the rule, the inequality is still additive, and the afternoon tide is still the greater. And this will continue to be the case till the points of no lunar declination are shifted away from the syzygies by the motion of the moon's nodes relative to the sun. But if the declination pass from north to south, or the reverse, at a different period from that which transfers the afternoon tides from one transit to the opposite one, we shall no longer have this apparent constancy in the relation of morning and afternoon tides. If, for instance, the tide hour being such as has already been supposed, the change of declination, north and south, takes place when the tide is at four, five, six, or seven o'clock; the afternoon tide will then (or rather one or two days later) change from being the greater to being the less, or *vice versâ*. Or if the tide-hour be six o'clock, the tide being (in general terms) six hours after the moon's transit, the afternoon tide will follow a south transit of the moon from the time when the moon is six hours west of the sun to the time when she is six hours east of him, and then change and follow a north transit; and so on alternately. Hence, if in this case the moon's ascending node be at six hours west from the sun, the declination will be north while the afternoon tide follows a south transit, and therefore the afternoon tide will be the greater for the whole lunation. But if, in this case, the node be in conjunction with the sun, the afternoon tide will change from smaller to larger, or the reverse, at syzygy, that is, when the tide is at six o'clock; or rather a day or two later.

"This last-mentioned circumstance, that the change in the features of the tides takes place a day or two, or perhaps longer, after the astronomical configuration by which it is determined, is common to all the empirical laws of the tides. It has recently been shewn by Mr. Airy that this is a result which follows from supposing the tidal motions of the sea to be affected by friction. The amount of this retardation of the phenomena for each place, or, as we may term it, the 'age of the tide' relative to the diurnal inequality, is different for different places; and

must, for each place, be learnt from observation;" as is shewn in our "Tides, British Ports," Tables 39 and 39a. (*See Admiralty Tide Tables*, 1860.)

"The inequality of heights appears in the *zigzag* form of the line drawn through the summits of ordinates projected from the heights of successive tides. This zigzag structure is sometimes of a moderate degree of abruptness, as in the tides of the coast of North America, and of Portugal, and those of Plymouth, and sometimes extremely abrupt, as the heights of low water at Singapore. In this latter case, the diurnal inequality sometimes makes a difference of no less than *six feet* between the height of the morning and afternoon tide; the whole rise of the mean tide being only seven feet at springs, and the difference of mean spring and neap tides not more than two feet.

"While in some places it affects the heights, and at other places principally affects the times, for instance, the diurnal inequality which alters the low-water four feet at Port Essington, and six feet at Singapore, affects the high water to a still greater extent in the Gulf of Cambay, and disturbs the times at the entrance of the Persian Gulf.

"It was remarked on the occasion of the observations of 1835, that the diurnal inequality on the coast of North America followed the changes of the moon's declination almost instantaneously; while on the coasts of Portugal, Spain, and France, the changes of lunar declination were represented in the diurnal inequality two or three days later; and at the Cape of Good Hope, about the same time. Dr. Whewell considers that this feature throws great difficulty in the conception of that motion of the waves by which the tides are produced, and suggests the necessity of some new mode of conceiving that motion. But we think the discrepancies are rather indicative of geographical and local variations *in the form of the ocean bed*, than any interference with the laws of fluid motion, which, however complicated in their details, are simple in their original forms. It is very certain that some of the most remarkable tides in the British coasts—as, for instance, the 18-inch spring-tide rise on one side of Fairhead, and the four-feet rise at a like distance on the other side of the same point, accompanied by terrible races and currents—similar phenomena also occurring at the Bill of Portland—are each and all mainly caused by bluff underwater cliffs, which directly reflect the tidal wave out of its course, and affect the superinduced flow of the water.

Plate V. is a chart of the globe with cotidal lines, compiled from Airy's treatise, and corrected from Whewell's papers. The coast lines give a vast amount of information touching the tide hours and times of high water approaching various shores and islands; in one point, however, we would suggest that there is room for much greater inquiry and speculation. As the tidal wave first proceeds from the sun and moon direct, much as if the ocean were pulled up over an enormous area, and then suddenly or as rapidly dropped again, it is clear that the wave must traverse, almost unchecked, in the depths of ocean adjacent to the equator; from this region it is natural to suppose, on the same principles of which we have positive proof in our channels and estuaries, that the waves diverge in a circular form, with velocities varying as influenced by depth and friction. Unfortunately, deep sea tides are beyond reach of experiment; but we imagine that it would meet the requirements of theory if the cotidal lines in the southern hemisphere were adjusted as encircling or radiating from the equator, as those in the northern side are shewn to do; this would affect not the hours along shore of South America, New Holland, and the Polynesian Islands, but the supposed direction in which the tide-wave works up the coasts; and if we take this view of the theory, it may account for many anomalies

in the tides of the complicated region round Singapore. Mr. Whewell's remark that the cotidal lines always run almost parallel to the shore, indicate how immediately the tide is retarded in velocity when coming out of deep water, and how large must be the radius of each progressive wave; his own remarks indicate the above hypothesis.

With regard to the semi-diurnal tide, we find it practically perceptible in the Thames, and it is also visible in the tides of the Humber. In a tidal canal branching from the Thames, which is under our management, it is found that at neap tides the inequality is highly useful by enabling advantage to be taken of the highest tide for keeping up the water to a better working level, there being occasionally nearly two feet difference; we have also experienced a similar advantage by the lower ebbing out in erecting tidal works at Plymouth.

It has become the practice of late to refer all levels to the Ordnance datum, which was the mean or half-tide level at Liverpool. Since this standard was adopted, numerous daily observations of the tide have been made all round the coast of England, in order to find the corrected mean level of the sea; these are given in Sir Henry James's volumes of the Ordnance levelling, and the *mean* of half-tide of all the places of observation appears to be .625 of a foot above the datum level or half tide at Liverpool, omitting the tides at Deptford, London Bridge and Battersea. The experimental inquiries are interesting, especially in examining our tables of tidal phenomena of the various rivers and estuaries. The facts indicate the effect of shoal bottom and form of channels on the tide-waves; probably the strongest effects are produced by the forced tide wave as formed in rivers and in cases where sand banks in the open sea have similar results. But it is manifest that in some cases the Ordnance observations did not extend over sufficient periods, and the tides were all taken during the day—6 a.m. to 6 p.m.—so that the mean tide level at many of the places would have to be corrected for the diurnal inequality. This is a point requiring careful notice, for the diurnal inequality has frequently a practical operation, unless duly considered; for instance, in the question of boundary of Crown lands on flat shores, where the difference of a few inches in determining mean high water would make important territorial alterations. Some of the tide curves given in plates XVI. and XVII. shew the diurnal inequality very strongly.

TIDES OF RIVERS AND ESTUARIES.

With a view to a more general knowledge and comparison of the tidal phenomena of English rivers, we have formed a collection* of the principal chacteristics of their tidal flow and ebb; of the velocity of the tidal wave, and other accompanying circumstances, such as the depth, width, and sectional area; and also the actual relative level of the water or tidal wave, at various points in the course of the respective rivers. We have placed the matter referring to each river and estuary at the end of each article, amounting to twenty-five tables, viz.:—

Tidal phenomena of the

Thames...2	pages.	Clyde.....3	pages.
Waveney 3	,,	Mersey ...3	,,
Nene 1	,,	Dee 1	,,
Humber...1	,,	Severn ...3	,,
Tyne 4	,,	Avon.....1	,,
Tay.....1	,,	Seine.....1	,,

* The collection has of course been gathered from various sources, as acknowledged in each case. Unless very great liberality had been shewn to me by professional friends, I could not have attempted the labour. One endeavour has been to adopt none but what could be relied on as strictly engineering surveys, and of undoubted accuracy.

And we have closed them with schedules of the size of the principal Docks in the United Kingdom, depth of sills, and other information, useful to shew the capability of the different ports, and accommodation in relation to their natural flow of tide, additional information on which is also given in the tables of the Tides of British Ports, Division I.

The following preliminary remarks upon each example will give an outline of the chief points of interest in each case; they should be read in conjunction with the tables of the tidal phenomena relating thereto.

THE RIVER THAMES.—Plates X. and XVI.

The River Thames has now a free tide-way up to Teddington Lock, near Richmond, but previously to the removal of old London Bridge it was, for all practical purposes, held up as by a weir at that point. Much discussion arose on the probable effect of its removal, and Messrs. Rennie conducted surveys for the City, at various periods, by Mr. Giles and others, to ascertain the probable effects; to save the reader labour of going through all the observations so ably put together by Mr. Rennie in his papers on Hydraulics, in the Reports of the British Association, we have laid together the following remarks and tables from this and other sources, endeavouring to trace down the various improvements and alterations in this great river; a careful perusal of the following statements will shew to the student or others seeking for examples the enormous advantage produced by removing obstacles to the full tidal flow.

Mr. Rennie quotes from the *Philosophical Transactions* for 1720, observations, taken in Lambeth Reach, of the Thames, by Mr. Saumarez, 8th and 19th June, 1719; we place them here in juxta-position with the most recent experiments on the present state of the river of which we have any record. The changes that have been produced in the navigation, and the health of the metropolis, by the maintenance of a more perfect tidal flow and ebb, would be shewn more strongly if we could give precisely similar observations at the same place up to a later date; for the dredging since has been very great, and there has been much natural lowering of the bed of the Thames by the increased scour at low water.

LAMBETH REACH, JUNE 8th and 19th.

	1720 and 1849.	
	H. M.	H. M.
Time of Flood Spring Tide	3 50	5 15
Ditto Flood Neap Tide	4 50	6 0
Ditto Ebb Spring Tide	8 40	7 5
Ditto Ebb Neap Tide	7 35	6 20

JUNE 19th, 1720 and 1834.

Miles run by Flood Spring Tide ...	5.25	11.20
Ditto Flood Neap do. ...	4.75	
Mean	5.00	
Ditto Ebb Spring do. ...	10.50	13.60
Ditto Ebb Neap do. ...	7.45	
Mean	9.12	

In the River Thames the tidal wave is now affected much less from friction and obstacles than might be expected. From reference to Mr. Lloyd's observations on the rise of the tides at Sheerness, with the mean of Mr. Lubbock's at the London Docks, it appears that in 1828—

			Feet.	Feet.
The spring tide high water at the London Docks, above the same at Sheerness, was			2.036	0.307
The mean high water	ditto	ditto	2.243	0.105
The neap tide	ditto	ditto	2.358	0.690
The spring tide low water	ditto	ditto	1.662	0.368
The mean level of the tides	ditto	ditto	2.036	
Or, taking more correctly the half difference between spring high and low water at Sheerness, the mean spring level is			1.725	

It seems, from the above summary, that, as the water decreases in height, so the height of the water's surface at London Docks above the same at Sheerness also decreases, with the exception of spring tides at the London Docks and at neap tides. The above are means, not of the highest tides, but of the tides at a particular time of the moon's southing. Trinity high-water mark at London Bridge was found by Mr. Lloyd to be 1.904 above mean spring tide high-water mark at Sheerness.

With respect to the influence of the winds on these tides. During strong north-westerly gales the tide marks high water earlier than otherwise, and does not give so much water, whilst the ebb runs out later and marks lower; but upon the gales abating and the weather moderating, the tides put in, and rise much higher, while they also run along after high water is marked, and with more velocity of current; nor do they run out so long or so low: a south-westerly gale has a contrary effect generally, and an easterly one gives some water; but the tides in all these cases always improve the moment the weather moderates.

Comparing observations taken at spring tides, for three days in March, 1833, before Old London Bridge foundations were removed, we find that high water at London Bridge was one hour 37 minutes after Sheerness; whereas now, in 1851, it is only 1 hour 20 minutes at spring tides later than at Sheerness.

			Ft.	Ins.
In March, 1833, the rise of tide at Sheerness was			18	7
Ditto	ditto	at Fresh Wharf	20	5
Ditto	ditto	at New London Bridge	18	3

Comparing the rise of these tides with those of June, 1849, in the sequel, it will be seen that the space between Deptford and London Bridge (although the fall of 2ft. 2ins. through the old bridge no longer obtains) is still the culminating point of the tidal wave of the Thames, owing to the narrowness of the river at this point, and quantity of ships at anchor in the pool. Thus—

			Ft.	Ins.	Time. H.	M.
Spring tide, June 20th, 1849, at Deptford*			20	8 ...	1	15
Ditto	ditto	at London Bridge	20	11½ ...	1	30
Ditto	computed for Sheerness		18	7 ...	11	55

But the most striking instance of the change in the tidal head of the Thames is shewn by the comparisons and data given in the following tables, which have been compiled from Mr. Rennie's treatise, and from Mr. Page's surveys, and from our own observations. We have embodied them with the experiments made for the Metropolitan Board of Works, in order to give a picture of what has occurred by the changes of this important river, thus offering data for future comparisons. The Thames is an instructive example, owing to the steady changes even now daily

* It is generally considered that the tide rises four inches higher at London Docks and makes ten minutes sooner. It is doubtful whether it does so with such a high spring tide as this; there is also not such a difference at neaps.

occurring by ballasting, which creates increased area and lowering of the bed upwards, *originating* from the removal of Old London Bridge. Its present state is brought up to 1849, in the tables devoted to tidal phenomena at the end of this article, and in Plate X., the materials for compiling which have been kindly furnished to the author by Mr. Leach, C.E., the engineer to the Thames Conservancy Board.

Plate X. gives a longitudinal section of the bed of the river in 1833 and 1861, with high and low water lines at spring and neap tides, from Teddington to Sheerness. The surface lines of the bed are plotted from the surveys of Mr. Giles (between Battersea and London Bridge) and Captain Bullock below London Bridge, made between 1823 and 1831, and from those made under direction of Captain Burstal, R.N., and Mr. Leach, between 1856 and 1861.

Plate XVI. contains simultaneous curves of spring and neap tides at several points, taken in 1857 by the Commission on Drainage of the Metropolis.

TIME AND HEIGHTS OF HIGH AND LOW WATER, in 1823 & 1845

Datum 20 feet below Trinity High Water, in this and all other Tables of the River Thames.

SPRING TIDE.

Stations.	April 29th, 1823.				April 25th, 1845.			
	High Water.		Low Water.		High Water.		Low Water.	
	Time.	Height	Time.	Height	Time.	Height	Time.	Height
	a.m. H. M.	Ft. Ins.	a.m. H. M.	Ft. Ins	p.m. H. M.	Ft. Ins	p.m. H. M.	Ft. Ins.
London Docks	4 15	19 0	11 18	2 6	4 13	20 3	11 45	0 9
Battersea Bridge	5 1	18 9	p.m. 0 45	8 6	4 50	20 1	0 40	5 7
Putney Bridge	5 13	19 0	1 5	9 8	5 0	20 0	1 15	6. 4
Kew Bridge	5 40	19 7	2 20	13 5	5 15	20 2	2 20	10 8
Teddington Lock	6 28	21 9	4 59	20 11	6 0	20 11½	a.m. 10 0	17 8½

NEAP TIDE.

Stations.	May 5th, 1823.				May 1st, 1845.			
	High Water.		Low Water.		High Water.		Low Water.	
	Time.	Height	Time.	Height	Time.	Height	Time.	Height
	p.m. H. M.	Ft. Ins.	a.m. H. M.	Ft. Ins	a.m. H. M.	Ft. Ins.	a.m. H. M.	Ft. Ins.
London Docks	9 7	15 3	3 21	1 9	9 45	17 0	4 35	1 0
Battersea Bridge	10 8	14 11	5 38	6 2	10 25	16 10	p.m. 6 10	5 4
Putney Bridge	10 31	15 2	6 35	8 3	10 55	16 11	a.m. 7 10	6 11
Kew Bridge	10 49	15 10	8 15	11 8	0 0	19 0	9 15	11 0
Teddington Lock	11 50	19 4	10 40	19 0	p.m. 0 20	18 4½	1 0* / p.m. 2 30	17 10½ / 17 10½

* This is evidently not the time of the commencement of the flood, but the time of low water; the down stream continuing for some hours afterwards.

COMPARATIVE SECTIONS BETWEEN WESTMINSTER AND LONDON BRIDGE.

Taken in 1823 and 1831 by Messrs. Rennie, and in 1845 by Mr. Page.

Locality.	Area below Low Water.			Area below Trinity High Water.		
	1823.	1831.	1845.	1823.	1831.	1845.
	Sup. Ft.	Sq. Ft.	Sq. Ft.	Sq. Ft.	Sq. Ft.	Sq. Ft.
250 yards north of Westminster Bridge	3,993	3,487	5,642	19,348	20,046	20,953
Near Whitehall Stairs	4,757	4,570	6,845	22,168	23,660	24,744
Near Hungerford Stairs	3,841	3,980	6,458	19,574	21,822	24,768
Waterloo Bridge	3,752	3,945	4,276	20,570	20,905	22,705
Bouverie Street	4,332	3,900	6,153	18,291	18,220	22,005
Between Blackfriars & Southwark Bridges	3,976	3,581	4,320	16,958	17,203 1832	1,6460 1834
London Bridge	...	...	...	17,360	17,650	17,600

TABLE OF VELOCITIES OF FLOOD AND EBB TIDE.

Giving the effect of removing old London Bridge.

	First of Flood.		Last of Flood.		First of Ebb.		Last of Ebb.	
	1831.	1833.	1831.	1833.	1831.	1833.	1831.	1833.
	Ft. per Min.	Ft. per Min.	Ft. per Min.	Ft. per Min.	Ft. per Min.	Ft. per Min.	Ft. per Min.	Ft. per Min.
Between Westminster & Waterloo Bridges	139.8	150.4	155.9	170.0	163.8	170.4	169.4	191.3
Waterloo & Blackfriars Bridges	149.4	172.9	184.8	209.7	186.0	218.6	196.3	238.9
Blackfriars & Southwark Bridges	158.1	174.2	259.6	268.1	262.3	277.7	252.0	295.6
Southwark & London Bridges	170.6	156.6	293.4	254.4	363.0	317.6	337.5	287.1

AVERAGE LEVELS OF HIGH AND LOW WATER, IN 1832, 1833, AND 1834.

Years.	No. of Tides in each Year.	Putney Bridge. Mean Level of		Kew Bridge. Mean Level of		Richmond Br. Mean Level of		Teddington Lk. Mean Level of	
		High Water.	Low Water.	High Water.	Low Water.	High Water.	Low Water.	High Water.	Low Water.
		Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.
1832	88	18 1	8 4	18 8	11 11	19 3	15 9	19 7	19 4
1833	84	18 6	8 8	19 2	12 6	19 9	16 4	19 2	20 0
1834	89	18 2	7 8	18 6	10 11	18 10	14 7	19 8	18 3

VELOCITIES OF FLOOD AND EBB TIDE, 19th JUNE, 1834.

(Wind W.S.W. Fresh breeze and clear). From experiments by Messrs. Rennie.

Stations.	Distance from London Bridge.	Flood Tide. (Read downwards.) Time.	Height at London Bridge.	Velocity per minute.	Ebb Tide. (Read upwards.) Time.	Height at London Bridge.	Velocity per minute.
	Miles.	h. m	Ft. Ins.	Feet.	h. m.	Ft. Ins.	Feet.
London Bridge	0.00	8 6	2 9	0.00	7 34	0 10	296.56
Southwark Bridge...	0.28	8 30	5 1	61.60	7 29	1 0	275.44
Blackfriars Bridge..	0.75	8 53	7 0	190.08	7 20	1 2	249.04
Waterloo Bridge.....	1.34	9 14	8 7	147.84	7 7	1 6	198.88
Hungerford Market	1.50	9 23	9 2	94.16	...	...	...
Westminster Bridge	2.00	9 36	10 9	202.40	6 50	1 11	224.40
Horseferry	2.42	9 50	11 2	160.16	6 40	2 2	198.00
Vauxhall Bridge.....	2.95	10 3	12 1	205.04	6 26	2 7	214.72
Chelsea Coll. Stairs	4.21	10 34	14 2	218 24	5 55	3 6	181.28
Chelsea Bridge	5.04	10 55	15 10	207.68	5 31	4 4	176.00
½-mile above ditto ...	5.54	11 9	16 10	188.32	5 16	4 10	195.36
1 mile ditto	6.04	11 20	17 6	240.24	5 2	5 4	176.00
1½ do. (Wandsworth)	6.54	11 31	18 0	240.24	4 47	5 11	195.36
Putney Bridge.....	7.48	11 50	18 9	290.40	4 21	7 0	67.36
2¼ miles	7.54	11 53	18 10	90.64	4 16	7 3	142.56
3 miles	8.04	12 6	19 3	211.20	3 58	8 0	146.96
3¼ miles	8.54	12 20	19 4	188.32	3 40	8 10	176.00
4 miles	9.04	12 30	19 4	264.00	3 25	9 5	146.08
Hammersmith Brdg.	9.20	12 35	19 2	176.00	3 19	9 7	185.68
5¼ miles	10.54	1 15	17 1	176.00	2 35	11 11	110.00
6 miles	11.04	1 35	15 7	132.00	2 11	13 3	119.68
6¼ miles	11.29	1 45	14 11	132.00	2 0	13 11	10.56
High Water at London Bridge	...	p.m. 12 20	19 4	...	p.m. 12 30	19 4	...
Low Water	..	a.m. 7 35	0 3	...	7 45	0 9	...

COMPARISON OF TIDES.

In 1823, Mr. Giles made the average velocity of flood tide between

London Bridge and Putney Bridge..... 220 feet per minute.
Ditto Southwark and Westminster 176 ,, ,,

The velocity of ebb tide he found to be

Between Westminster and Waterloo Bridges ... 176 ,, ,,
,, Waterloo and Blackfriars Bridges ..... 198 ,, ,,
,, Blackfriars and London Bridges..... 242 ,, ,,

Finally, Mr. Rennie states that the sectional area at Old London Bridge, below Trinity High Water level—

Before removal in 1832 was ..... 8,700 sup. feet.
After do. 1834 ,, ... 17,600 do.

	Greatest. ft. in.	Least. ft. in.
At Old London Bridge the fall through was, in 1832 ...	3 6	1 10
Ditto ditto in 1834 ...	0 5	0 3
Range of Spring Tides ..... in 1832 ...	16 9	
Ditto ditto ..... in 1834 ...	19 9	
Low Water Springs below Trinity datum... in 1832 ...	15 5	
Ditto ditto ... in 1834 ...	20 3	

TIDES OF THE THAMES.

TABLE OF THE RISE AND FALL OF A SPRING AND NEAP TIDE

At the undermentioned points, taken simultaneously from the Ordnance Metropolitan Survey observations, in 1849.

Note.—Zero is 20 feet below the Ordnance datum or mean half-tide level at Liverpool, which is 12.5 below Trinity high water standard.

SPRING TIDE, June 20th, 1849.				NEAP TIDE, June 30th, 1849.			
TIME.	Deptford.	London Bridge.	Battersea.	TIME.	Deptford.	London Bridge.	Battersea.
H. M.	Feet.	Feet.	Feet.	H. M.	Feet	Feet.	Feet.
7 30 a.m.	13.62 LW	15.00	17.25	7 30 a.m.	24.07	23.70	20.90
8 0 „	13.66	14.25	16.60	8 0 „	25.78	25.40	22.55
8 30 „	15.43	14.66	16.05	8 30 „	27.32	27.00	24.10
9 0 „	18.27	17.60	15.60 LW	9 0 „	28.71	28.45	25.75
9 30 „	20.85	20.80	17.75	9 30 „	29.62	29.60	27.15
10 0 „	23.56	23.05	19.80	10 0 „	30.10	30.20	28.50
10 30 „	25.77	25.40	22.15	10 30 „	29.70	30.30	28.95
11 0 „	27.68	27.40	24.35	11 0 „	28.22	29.30	28.80
11 30 „	29.18	28.80	26.30	11 30 „	26.47	27.60	27.50
12 0 „	30.52	30.30	27.85	12 0 „	24.67	25.90	26.10
0 30 p.m.	31.68	31.60	29.35	0 30 p.m.	23.10	24.40	24.70
1 0 „	32.73	32.80	30.80	1 0 „	21.65	23.00	23.45
1 30 „	32.85	33.45 HW	31.85	1 30 „	20.33	21.60	22.25
2 0 „	31.73	32.75	32.15 HW	2 0 „	19.00	20.30	21.10
2 30 „	29.64	30.95	31.20	2 30 „	17.90	19.20	20.15
3 0 „	27.43	29.00	29.20	3 0 „	16.21	18.10	19.15
3 30 „	25.48	27.00	27.50	3 30 „	16.08	17.15	18.35
4 0 „	23.73	25.30	26.10	4 0 „	15.49	16.30	17.65
4 30 „	22.12	23.80	24.70	4 30 „	15.80	15.90	17.00
5 0 „	20.56	22.25	23.40	5 0 „	17.13	16.80	16.40
5 30 „	19.14	20.85	22.10	5 30 „	18.62	18.45	16.40
7 55 a.m.	13.60 LW	.. ..		10 5 a.m.	30.15 HW	.. ..	.. ..
8 15 „	.. ..	14.15 LW		10 20 „	.. ..	30.30 HW	.. ..
1 15 p.m.	33.14 HW	.. ..		10 40 „	.. ..	.. ..	29.05 HW
				4 10 p.m.	15.39 LW	.. ..	.. ..
				4 40 „	.. ..	15.80 LW	.. ..
				5 20 „	.. ..	.. ..	16.10 LW

VELOCITIES OF THE HEAD AND FOOT OF A TIDAL WAVE,

From the above observations.

SPRING TIDE, June 20th, 1849.

STATIONS	Distances Apart.	Tidal Range.	Interval of Passage of		Rate per Minute.	
			Foot of Wave.	Head of Wave.	Foot.	Head.
Between	Feet.	Feet.	Mins.	Mins.	Feet.	Feet.
Deptford and London Bridge	20,600	19.54 D	20	15	1,030	1,373
London Bridge and Battersea.....	25,700	19.30 L	45	30	571	856.6
Deptford and Battersea.....	46,300	16.55 B	65	45	712.3	1028.8

NEAP TIDE, June 20th, 1849.

STATIONS.	Distances Apart.	Tidal Range.	Interval of Passage of		Rate per Minute.	
			Foot of Wave.	Head of Wave.	Foot.	Head.
Between	Feet.	Feet.	Mins.	Mins.	Feet.	Feet.
Deptford and London Bridge	20,600	14.76 D	30	15	686.6	1,373.2
London Bridge and Battersea	25,700	14.50 L	40	20	642,5	1,285.0
Deptford and Battersea.....	46,300	12.95 B	70	35	661.4	1,323

TIDES OF THE THAMES.

VELOCITIES OF THE HEAD AND FOOT OF A TIDAL WAVE,

At a Spring and Neap Tide, from St. Katharine's Docks to Teddington Lock, from Mr. Page's observations in 1845.

SPRING TIDE, April 25th, 1845.

Names of Stations.	Distances apart.	Tidal Range	Interval of Passage of		Rate per Minute.	
			Foot of Wave	Head of Wave	Foot.	Head.
Between	Feet.	Ft. In.	Mins.	Mins.	Feet.	Feet.
St. Katharine's Docks and Battersea Br.	29,160	19.75K	70	37	429	788
Battersea Bridge and Putney Bridge	15,840	14.50B	35	10	452.6	1,584
Putney Bridge and Kew Bridge	29,700	12.67P	65	15	457	1,980
Kew Bridge and Teddington Lock	26,400	9.49K	..	45	..	587
St. Katharine's Docks and Tedding. Lock	101,100	3.25 T	..	107	..	945

NEAP TIDE, May 1st, 1845.

Names of Stations.	Distances apart.	Tidal Range	Interval of Passage of		Rate per Minute.	
			Foot of Wave	Head of Wave	Foot.	Head.
Between	Feet.	Ft. In.	Mins.	Mins.	Feet.	Feet.
St. Katharine's Docks and Battersea Br.	29,160	15.50K	85	40	343	729
Battersea Bridge and Putney Bridge	15,840	11.50B	..	30	..	528
Putney Bridge and Kew Bridge	29,700	10. 0 P	..	20	..	1,485
Kew Bridge and Teddington Lock	26,400	6.16K	..	65	..	406
St. Katharine's Docks and Tedding. Lock	101,100	0.50 T	..	155	..	652.6

RESULTS OF THE TIDAL OBSERVATIONS,

TAKEN FOR THE ORDNANCE SURVEY OF THE METROPOLIS,

BETWEEN 19th JUNE and 19th JULY, 1849,

Taken in 10 *Minutes' observations.*

The zero of the heights is 20 feet below Ordnance datum or mean half-tide at Liverpool.	Deptford.	London Bridge.	Battersea.
	Feet.	Feet.	Feet.
Highest High Water observed during the month	33.14	33.45	32.15
Lowest Low Water „ „	10.81	11.75	14.45
Mean High Water for the month	30.98	31.23	29.95
„ Low Water „	13.06	13.65	15.04
Mean Half-tide „	22.02	22.44	22.50
Mean Half-tide at London, above approximate Half-tide at Liverpool	2.02	2.44	2.50

HEIGHT OF TRINITY HIGH WATER MARKS ABOVE ZERO.

Mark at Lomer's Quay, Billingsgate	32.36	Feet.
„ Hermitage Entrance, London Docks	32.50	„
„ Shadwell Entrance, London Docks.....	32.59	„
„ Limehouse Entrance, West India Dock Basin.....	32.75	„
„ „ South Dock	32.71	„
„ Blackwall Entrance, South Dock.....	32.73	„
„ „ West India Dock	32.77	„

THE RIVERS WAVENEY AND YARE.

The nature of the tidal flow of these rivers is given in the three following tables. from observations taken in 1850 with great accuracy, under our own direction.

Uniting with the Yare between St. Olave's and Burgh Flats, the joint rivers are emptied by a long narrow channel leading to Yarmouth pier, about 1½ miles below the town; this channel and the shoal expanse of Burgh Flats offer great obstruction to the passage of tide and flood waters. The tabulated observations pass from the sea at Yarmouth and upwards until where the river spreads into a large lake called Burgh Flats; they are continued by St. Olave's Bridge, where the Yare has divided off from the Waveney proper, and pass on to Beccles. We give also the simultaneous height of the water at the Mutford Lock (Waveney side), and of the sea at Lowestoft pier. This river is well known to be extremely sluggish in its tidal flow; the form of its mouth and wide expanse of Burgh Flats, with the want of a straight and deep channel, give all the conditions for bad propagation of the wave, consequently small oscillation of tide, and deficient drainage. Mutford lock is remarkable as a point where local jealousy of interference with back water, now flowing out by the Yarmouth river, compelled the construction of a lock and gates so arranged as to prevent any tidal flow passing to or from the Lowestoft entrance; thus destroying all chance of stimulating the tidal wave. If the passage were free, these two points, viz., the north side of Mutford lock, and Lowestoft pier, being only four miles distant, would have but little difference in their tidal flow, while a greatly increased fall at low tide would be carried on towards St. Olave's Bridge. This would benefit all interests, and prejudice none, if proper arrangements were made simultaneously with relation to the Yarmouth river. An immense district of marshes exists here, with inefficient embankments and outfall; both of which might be improved by the simple operation of dredging. In flood-time, the rivers between Yarmouth and Norwich on the east, and Mutford on the south, in length 26 miles and upwards, overflow and submerge, unnecessarily, a great breadth of marsh lands. This area is very similar on a small scale to the lagoons of the American coast, and dates its origin probably from sinking of the interior or upheaval of the belt of high land which forms the sea coast between Lowestoft and Yarmouth. The surface strata generally partakes of the character of fen land; the depths of water in the channel are generally small, but there are exceptions where deep portions prevail either from depressions or the presence of strong bottom springs; much of the bottom soil of this district is light silt for a very great depth, as if there were partial depressions filled up with floating lacustrine deposits.

TIDES OF THE WAVENEY.

TABLE OF THE RISE AND FALL OF THE TIDE

At various points, taken simultaneously from the mouth of the river at Yarmouth to Beccles, and at Lowestoft.

Datum line 5 feet below Old Zero at Mutford Bridge.

NEAP TIDE, March 21st, 1850.

Time.	Yarmouth Pier.	Yarmouth Bridge.	Burgh Flats.	St. Olave's.	Burgh St. Peter's.	Beccles	Mutford Lock, N. Side.	Lowestoft Pier.
H. M.	Ft. Ins.	Ft Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft Ins	Ft. Ins.
6 0 a.m	3 3½	4 0½	4 6½	5 1½	5 3½	5 5	5 5½	3 6
6 30 „	2 8½	3 9½	4 4½	5 0½	5 4½	5 5½	5 5½	3 0
7 0 „	2 5½	3 5½	4 2½	4 11½	5 3½	5 5½	5 4½	2 6
7 30 „	2 1½	3 3½	4 1½	4 9½	5 2½	5 4½	5 3½	2 0
8 0 „	1 11½	3 1½	4 0½	4 8½	5 2½	5 3½	5 2½	1 9
8 30 „	1 9½	2 11½	3 11½	4 7½	5 0½	5 2½	5 1½	1 6
9 0 „	1 11½	2 10½	3 9½	4 6½	4 11½	5 1½	5 0½	1 7
9 30 „	2 4½	2 11½	3 8½	4 5½	4 10½	5 0½	4 11½	1 10
10 0 „	2 9½	3 1½	3 8½	4 4½	4 9½	4 11½	4 10½	2 5
10 30 „	3 5½	3 5½	3 7½	4 3½	4 8½	4 10½	4 9½	2 11
11 0 „	4 0½	3 9½	3 9½	4 2½	4 7½	4 9½	4 8½	3 7
11 30 „	4 4½	3 11½	4 0½	4 2½	4 6½	4 8	4 7½	4 0
12 0 „	4 6½	4 1½	4 2½	4 3½	4 6½	4 7½	4 6½	4 3
0 30 p.m.	4 8½	4 4½	4 3½	4 5½	4 5½	4 6½	4 5½	4 6
1 0 „	4 10½	4 6½	4 5½	4 6½	4 6½	4 6	4 6	4 9
1 30 „	4 11½	4 7½	4 6½	4 7½	4 7½	4 6	4 7	5 0
2 0 „	5 0½	4 8½	4 7½	4 8½	4 8½	4 6½	4 8	5 3
2 30 „	5 0½	4 8½	4 8½	4 9½	4 9½	4 7½	4 9	5 5
3 0 „	4 11½	4 8½	4 8½	4 10½	4 10½	4 9	4 10	5 6
3 30 „	4 9½	4 7½	4 9½	4 11½	4 11½	4 10½	4 11	5 4
4 0 „	4 3½	4 5½	4 8½	4 11½	5 0½	4 10½	5 0	4 11
4 30 „	3 9½	4 3½	4 6½	5 0½	5 0½	5 0	5 0½	4 5
5 0 „	3 3½	3 11½	4 2½	4 11½	5 1½	5 1	5 1½	4 0
5 30 „	2 10½	3 8½	4 2½	4 10½	5 1½	5 1½	5 1½	3 7
6 0 „	2 5½	3 4½	4 1½	4 9½	5 0½	5 1½	5 0½	3 0

TIDES OF THE WAVENEY.

TABLE OF THE RISE AND FALL OF THE TIDE

At various points, taken simultaneously from the mouth of the river at Yarmouth to Beccles and at Lowestoft.

Datum line 5 feet below Old Zero at Mutford Bridge.

SPRING TIDE, March 29th, 1850.

Time.		Yarmouth Pier.		Yarmouth Bridge.		Burgh Flats.		St. Olave's.		Burgh St. Peter's.		Beccles		Mutford Lock, N. Side.		Lowestoft Pier.	
H.	M.	Ft.	Ins.	Ft.	Ins.	Ft.	Ins.	Ft.	Ins.	Ft.	Ins.	Ft.	Ins.	Ft.	Ins.	Ft.	Ins.
6	0 a.m	2	6½	2	7½	3	1⅝	3	11⅝	4	5⅛	4	6⅛	4	5⅝	1	6
6	30 „	3	11½	3	6½	3	1⅝	3	11½	4	4½	4	5½	4	4½	3	0
7	0 „	4	7½	4	0½	3	4⅝	3	10⅝	4	3½	4	4⅝	4	3½	3	10
7	30 „	5	0½	4	4½	3	9½	4	0⅝	4	2½	4	3½	4	2½	4	4
8	0 „	5	3½	4	7½	4	0½	4	2½	4	1½	4	2½	4	1½	4	8
8	30 „	5	5½	4	9½	4	2⅝	4	3⅝	4	2½	4	1½	4	1½	5	1
9	0 „	5	9½	4	10½	4	5⅝	4	5⅝	4	3½	4	1	4	2½	5	5
9	30 „	5	10½	5	0½	4	6⅝	4	6⅝	4	4½	4	1¾	4	4	5	9
10	0 „	5	10½	5	1½	4	8⅝	4	8⅝	4	5⅝	4	3½	4	5⅝	6	1
10	30 „	5	9½	5	1½	4	9⅝	4	10⅝	4	7½	4	5½	4	7	6	5
11	0 „	5	7½	5	1½	4	11⅝	4	11⅝	4	8⅝	4	7½	4	8½	6	3
11	30 „	5	0½	5	0½	5	0⅝	5	1⅝	4	10½	4	9½	4	9⅝	5	9
12	0 „	4	3½	4	9½	5	0⅝	5	2⅝	5	0½	4	10⅝	4	11½	5	0
0	30 p.m.	3	2½	4	2½	5	0½	5	3½	5	1½	4	11⅝	5	1	4	1
1	0 „	2	6½	3	9½	4	7⅝	5	1½	5	1⅝	5	0½	5	2	3	11
1	30 „	2	1½	3	6½	4	5½	4	11½	5	1⅝	5	1⅝	5	2½	2	9
2	0 „	1	7½	3	3½	4	2⅝	4	9⅝	5	1½	5	2⅝	5	2	1	11
2	30 „	1	1½	2	11½	4	0⅝	4	8½	5	0⅝	5	2½	5	1	1	5
3	0 „	0	8½	2	7½	3	10⅝	4	6½	4	11½	5	1½	4	11⅝	0	10
3	30 „	0	4½	2	4½	3	9⅝	4	5⅝	4	10½	5	0½	4	10	0	1
4	0 „	0	2½	2	2½	3	7⅝	4	4⅝	4	8⅝	4	11½	4	9½	below zero 0	3
4	30 „	0	1½	2	0½	3	6⅝	4	3⅝	4	7⅝	4	10½	4	8½	0	7
5	0 „	0	3½	1	11½	3	5⅝	4	1⅝	4	6⅝	4	9	4	7	0	3
5	30 „	0	2½	1	11½	3	4⅝	4	0⅝	4	5⅝	4	8	4	6	0	0
6	0 „	0	3½	2	1½	3	3⅝	3	11⅝	4	4½	4	6⅝	4	4⅝	above 1	8

TIDES OF THE WAVENEY.

TABLE OF VELOCITIES OF THE HEAD AND FOOT OF TIDAL WAVE,

From Yarmouth Pier to Beccles Bridge, and to Lowestoft, at a Spring and Neap Tide.

NEAP TIDE, March 21st, 1850.

Names of Stations.	Distances apart.	Tidal Range	Interval of Passage of Foot of Wave	Interval of Passage of Head of Wave	Rate per Minute. Foot.	Rate per Minute. Head.
Between	Feet.	Ft. In.	H. M.	H. M.	Feet.	Feet.
Yarmouth Pier and Yarmouth Bridge ...	13,860	3 3	0 30	0 30	462	462
Yarmouth Bridge and Burgh Flats.....	20,988	1 10	1 30	0 30	233	700
Burgh Flats and St. Olave's	26,070	1 2	0 30	1 0	869	434.5
St. Olave's and Burgh St. Peter's.....	29,436	0 10	1 30	0 30	327	981.2
Burgh St. Peter's and Beccles	34,980	0 7½	0 30	1 30	116.6	388.7
Yarmouth Pier and Beccles	125,334	B 11½	4 30	4 0	464.2	522.8
Yarmouth Pier and Lowestoft	38,148	4 0	..	0 30	..	1271.6

SPRING TIDE, March 29th, 1850.

Names of Stations.	Distances apart.	Tidal Range	Interval of Passage of Foot of Wave	Interval of Passage of Head of Wave	Rate per Minute. Foot	Rate per Minute. Head.
Between	Feet.	Ft. In.	H. M.	H. M.	Feet.	Feet.
Yarmouth Pier and Yarmouth Bridge ...	13,860	5 9	0 30	1 0	462	231
Yarmouth Bridge and Burgh Flats.....	20,988	3 2	1 30	1 0	462	349.8
Burgh Flats and St. Olave's	26,070	1 11	1 0	1 0	434.5	434.5
St. Olave's and Burgh St. Peter's.....	29,436	1 4½	1 0	0 30	491.6	981.2
Burgh St. Peter's and Beccles	34,980	1 0½	1 0	1 0	583	583
Yarmouth Pier and Beccles	125,334	1 1½	5 0	4 30	417.8	464.2
Yarmouth Pier and Lowestoft	38,148	7 0	..	1 0	..	635.8

THE RIVER NENE.—Plate IX.

In the early part of this century, Fen lands to an extent of at least 200,000 acres, drained by this river, were entirely waterlogged in moderately wet seasons. In the past forty years, embankments have been improved and extended; great drains have been cut through the embanked lands, with direct outfalls on the Ouse, Nene, and Welland; more recently steam has been applied to Whittlesea Mere and other low parts, and consequently at present there are no low countries more free from hurtful presence of water than the great delta forming the outfalls of the Nene, Ouse, and Welland Rivers. The great original source of all these improvements has been in the new deep water courses through the old wandering channels and shallow sea banks forming the debateable ground where flood waters and the tide fought for possession.

In the year 1813 the Commissioners of the North Level (drained by the river Nene) applied to Mr. Rennie for advice, which he gave in the following year; from his observations it then appeared that the fall at low water from Sutton Wash to Crab Hole (below the sands of the Wash) was 12 feet in about 4 miles; from the surface of the water at Gunthorpe Sluice to Crab Hole, a distance of 5½ miles, the fall was 13 feet; from Guyhirn to Crab Hole, a distance of 17 miles, the fall was 14 feet 6 inches; and from Peterborough bridge to the same point, a distance of 30½ miles, the fall was only 18 feet 6 inches.

It appeared, therefore, evident that the great bar to the discharge of the waters of the Nene, and of course to the general drainage of the fens, was the high and shifting sands between Gunthorpe sluice and Crab Hole, independently of the narrow and confined state of the river above; Mr. Rennie, therefore, recommended the river to be carried by a new cut, of a suitable capacity, across the marshes to Crab Hole, 5½ miles in length.

The Nene outfall cut was executed under the direction of Messrs. Telford and Rennie, and completed in 1834; the original dimensions are given below, but the section has deepened and generally improved since completion; its effects exceeded the most sanguine expectations, having reduced the fall between Crab Hole and Gunthorpe to about three inches per mile, where it was formerly more than two feet per mile; low water below Sutton Bridge being now five feet below that at King's Lynn, on the Ouse. The scouring effect was so great, that the Sutton Wash Bridge, erected during the progress of the work, was in great danger of being undermined, requiring stone to be thrown in, much to the detriment of greater improvement of the river. This was amended in 1850 by the construction of a new bridge, after which the old one was removed. The sill of the North Level sluice, laid 5 feet deeper during construction of the Nene outfall, has also been lowered since this date more than two feet. These facts are given by Mr. Utting, late Surveyor to the Commissioners. He states that the Nene outfall lowered the water at the North Level sluice ten feet; in the town of Wisbech, spring tides rose four feet only, and now rise thirteen feet; and neap tides, which in 1769 did not reach the town, now rise nine feet

In the Nene, between the North Level sluice and Sutton Bridge, the fall in the ordinary state of the river does not exceed 1½ or 2 inches per mile; and at the height of the flood of March, 1848, it did not exceed 4 inches per mile; and at the same time, the fall from the Horseshoe to the North Level sluice (4½ miles), was only 6 inches more than ordinary. Below Sutton Bridge, the fall is ordinarily about 1 inch per mile, though the surface of low water is frequently level.

From March 13th to 26th, 1848, low water at Sutton Bridge, was, on the average, 4 feet, 8.6 inches lower than at Free Bridge, on the Ouse.

The paper on arterial drainage, recently laid before the Institute of Civil Engineers, by Mr. R. B. Grantham, C.E., contains a vast amount of information on arterial drainage and outfalls. This authority gives the original dimensions of the lower end of the new outfall, at Crabhole, width at top, 270 feet, at bottom, 165 feet; at the upper end of Kinderley's cut, width at top, 200 feet; at bottom, 135 feet; the depth in both cases was 24 feet, giving 8 feet depth at low water. The cost of the Nene outfall cut was £200,716 for the length of 5½ miles.

Since its construction, more especially within the first few years after 1830, the date of its opening, the cut scoured itself out immensely, so that the present dimensions for the upper end of the Nene outfall cut are about 410 feet wide at top, or at the level of high water spring tides; 250 feet wide at bottom, and 20 to 26 feet deep; giving an area of about 7,000 to 8,000 square feet.

The main drain of the New North Level Drainage works, which followed the construction of the Nene outfall, was for the first 8¼ miles from the sluice laid eight feet deeper in level than the old shire drain, and with six times its sectional area; but this drain has since been considerably deepened. The North Level sluice had 36 feet of width given in lieu of 17 feet, and the sill was laid five feet deeper; this has been, since 1851, again lowered 2 feet, owing to the advantage gained by rebuilding Sutton Bridge.

The North Level Commissioners spent £150,000 on the drainage of 200,000 acres, in addition to a contribution of £140,000 towards the cost of the outfall above mentioned.

Notwithstanding the enormous advantage of this outfall to the lands around and below Wisbech, yet the narrowness between the banks in that town and its old bridge had the effect of keeping up the waters of the upper Nene, so that there was from two to four feet of fall through Wisbech at low water. Tables of tidal observations, shewing the rise, surface fall, and sectional areas of the Nene, are given at page 238, from our own observations, taken before the execution of the new bridge and other improvements in Wisbech.

The attempts which have been made to improve the river through and above Wisbech, have never yet been properly completed; this is as much from pecuniary difficulties as from defective engineering, for an enormous area of land which should have been more naturally drained by the Nene, with an advantage of five feet fall, is now carried by the Middle Level drainage into the Ouse. This has greatly limited the taxable area; there is, however, ample inducement for an improvement of the Nene, both in respect of drainage and of navigation; for the banks and narrows above Wisbech, especially [redacted] Guyhirn, render the river little better than a shallow pond; although properly improved, it would have a very free and considerable tidal ebb and flow, even at neaps. The banks in this case will require great alteration above Guyhirn, for decidedly higher springs will be admitted up to Morton's Leam and Peterborough, if improvements are carried out in the manner prescribed by Parliament.

In reference to the continued deepening so notably required for drains and outfalls in these fen countries, it is well known that the removal of water has the effect of lowering the land itself, so that steam draining engines require to be altered from time to time as they effect the drainage of the surrounding lands; the same cause has always necessitated the deepening from time to time of drains in fen lands originally constructed in the most effective manner. The early history of all new sea enclosures and drainages is that of progressive improvement.

TIDES OF THE NENE.

TIMES AND HEIGHTS OF HIGH AND LOW WATER, AT SPRING AND NEAP TIDES,

With Sectional Area, Width and Depth at each place.

From observations taken under the direction of J. M. Rendel, Esq., F.R.S.

Datum Cill of the North Level Sluice.

Stations and Sections of River at High Water, April 17th, 1851.	Distances.	Spring Tide, April 17, 1851.				Neap Tide, April 24, 1851.			
		High Water.		Low Water.		High Water.		Low Water.	
		Time.	Height	Time.	Height	Time.	Height	Time.	Height
Area. Wdth. Dpth. Sq.Ft. Ft. Ft.	Feet.	H. M. a.m.	Ft. In.	H. M. a.m.	Ft. In.	H. M. p.m.	Ft. In.	H. M. a.m.	Ft. In.
Horseshoe	..	8 15	20 0	5 30	5 3	0 55	13 0	9 0	5 6
Phillips' Brewery 1563 120 x 19	6,600	8 20	19 6	5 20	8 6	1 5	12 9	9 45	7 7
Waldersea Sluice 1464 112 x 23	12,540	8 50	19 1	6 0	11 1	2 10	13 0	10 30 p.m.	9 11
Guyhirn..... 1432 140 x 14	16,500	9 20	18 9	7 15	13 6	1 55	14 2	0 10	11 9
Cross Guns ..... 421 57 x 12	17,160	10 0	16 9	8 0	14 10	3 15	13 9	1 20	13 3
Dog and Doublet 736 82 x 8	25,080	11 5	16 6	9 5	16 5	4 20	15 3	2 20	15 2
Peterborough ... 500 60 x 9	27,720	p.m. 1 5	16 5	11 0	16 7	6 20	16 0	4 20	16 0
	105,600								

INCLINATION OF RIVER SURFACE AT TIMES OF HIGH AND LOW WATER AT WISBEACH.

Stations and Sections of River at Low Water, April 17th, 1851.	Distances.	Spring Tide, April 17, 1851.				Neap Tide, April 24, 1851.			
		Height on Gauge.		Inclination ⅌ Mile.		Height on Gauge.		Inclination ⅌ Mile.	
		At H. W.	At L. W.	At H. W. Fall.	At L. W. Rise.	At H. W.	At L. W.	At H. W. Fall.	At L. W. Rise.
Area. Wdth. Dpth. Sq.Ft. Ft. Ft.	Feet.	Ft. In.	Ft. In.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
Horseshoe	..	20 0	5 3	..	..	13 0	5 6	..	..
Wisbeach Bridge	4,620	19 10	7 1	.185	2.091	12 10	6 7	.185	1.234
Phillips' Brewery 469 80 x 8	1,980	19 5	8 5	1.120	3.547	12 7	7 8	.666	2.880
Waldersea Sluice 709 78 x 15	12,540	18 6	11 2	.387	1.157	12 0½	10 0	.227	.981
Guyhirn..... 678 130 x 9	16,500	17 0	14 3	.480	.985	12 11	12 11	Rise. .281	.934
Cross Guns ..... 317 45 x 10	17,160	16 1½	15 0	.270 Rise.	.230	13 2	13 2	.077	.077
Dog and Doublet 730 82 x 8	25,080	16 3	16 3	.025	.263	15 1	15 1	.400	.400
Peterborough ... 500 60 x 9	27,720	16 7	16 7	.063	.063	15 6	15 6	.080	.080
	105,600			.171	.566			.125	.500

THE RIVER OUSE,

Another of the rivers emptying into the Wash, has a marked bore, which, like that of the Severn, is created by the shoals at the mouth below Lynn, causing a greater fall at the outlet than further up the river. We believe this will be found to be universally the case where the bore prevails. The ocean tidal wave comes up from deep water, and meeting with the sudden rise and resistance of the bed, the wave assumes a head which, too great for its depth, topples over in the characteristic form of the bore.

The Eau Brink cut, originally projected by Mr. Nathaniel Kinderley, in the year 1720, was completed by Mr. Rennie in 1825, according to the award of Messrs. Huddart and Mylne; its object was to conduct the waters of the river Ouse by a direct cut across the marshes from Eau Brink to Lynn, a distance of two miles and a half, instead of allowing them to flow by the old circuitous channel, upwards of five miles in length.

The area of Eau Brink cut, just below Freebridge, at low water spring tides, or 2 ft. 3 ins. on Freebridge gauge, is 2,620 square feet, the depth then being 11 ft. 9 ins. and width at water line 312 feet.

The area at high water springs, rising to 16 ft. 9 ins. on the same gauge, is 7,879 square feet, the depth then being 26 ft. 3 ins., and width at water line 412 feet.

In December, 1821, the tide rose on the average eleven feet ten inches on the sill of Old Denver Sluice; while at low water the average depth on the sill was 9.6 inches.

Since the completion of the Eau Brink Cut, the results have been*—

That the low-water mark has fallen six feet lower than it formerly stood at Denver Sluice, and from eight to nine feet at Eau Brink:

That the spring tides now rise at Denver Sluice thirteen feet, and neap tides eight feet:

That the river has deepened between Danver Sluice and Eau Brink ten feet upon the average, and its general sectional area has increased naturally since the spring from one-fourth to one-third:

That the low-water mark in Lynn harbour has fallen four feet, and the navigable channel in Lynn harbour has deepened seven feet; and that where they were formerly twelve feet in depth of water in the intercepted bed of the old Ouse between Eau Brink and Lynn, there is now a tract of 900 acres of land under cultivation, all of which has been effected by the process of warping.

The tide in the Eau Brink flows three hours, and rises in that time fifteen feet, at spring tides, thus leaving nine hours of ebb; the young flood then assumes all the characteristics of a bore, rising at the first two minutes from one to three feet, and subsiding again, for a short time, to half the first height when the wave has passed on.

Between February 21st and April 2nd, 1848, during the prevalence of the heaviest flood that had occurred for several years, the average fall per mile on the surface of low water, from Denver Sluice to Free Bridge, was under 7¾ inches per mile, and the maximum inclination was, on March 23rd, less than 9 inches per mile. Also, during the six weeks' flood, from October 9th to November 19th, 1848, the average fall was less than 7 ins. per mile, and the maximum under 9 ins. per mile. During the fourteen

* This sketch of the results of the Eau Brink Cut is chiefly from Mr. G. Rennie's Report on Hydraulics; the work was finished in 1821, at a cost of £600,000, distributed over an area of 250,000 acres. About 150,000 acres of this level have since borne the cost of the Middle Level Drainage works, amounting to more than £410,000, as executed between 1847 and 1852. The general effect of the Middle Level Drainage works has been to lower the waters six feet throughout the level.

weeks, from November 15th, 1847, to February 20th, 1848, the average fall was 6½ ins. per mile; and from November 15th, 1847, to April 16th, 1848, the average fall was less than 7 ins. per mile.

On the 16th July, 1849, the total fall from Denver Sluice to Free Bridge, was only 2 ft. 9 ins., or 2.6 ins. per mile, for 12 miles 5 furlongs.

Notwithstanding the enormous improvement by the Eau Brink Cut, low water spring tides at King's Lynn were about five feet higher than in the roads at the entrance of the river, owing to the circuitous course of the channel, and the prevalence of banks of sand and mud. To remedy these defects and to form the great Estuary of the Wash enclosure, Sir John Rennie designed a new outfall from opposite King's Lynn to the Roads, a length of four miles, which has the practical effect of bringing dead low water up to Lynn, or, in other words, lowers the water at the end of Eau Brink Cut from 5 to 6 feet.

This new cut is 250 feet wide at bottom, and 500 feet wide at top, and 32 feet deep; it is 14 ft. 3 ins. deep at low water spring tides, or 2 ft. 3 ins. on Freebridge gauge, with an area at low water line of 3,960 square feet, and width of 355 feet.

The depth of the cut at high water spring tides, or 16 ft. 9 ins. on Freebridge gauge, was designed to be 28 ft. 9 ins. with an area at low water line of 9,990 square feet, and width of 474 feet.

The cut passes inland for two miles, and the remaining two miles crosses the channel and sand banks of the estuary into Lynn deeps; the first portion, containing about four millions of cubic yards, was executed very rapidly (say two years) in 1851-52, by the vigorous appliances of Messrs. Peto and Betts, forming a work at the present moment highly interesting to an engineer.

Fen land ranges from 8 to 14 ft. above dead low water at sea; it is therefore evident that fall is of the utmost importance, seeing that some of the lowest parts are 23 to 30 miles from the final outfall at sea.

The present Nene and Ouse are essentially artificial rivers, and the tidal flow is maintained by embankments of expensive character, some portions of which date from the Roman era, but the more important and systematical banks have been made since A.D. 1639, which is the date of the Great Bedford Level Embankments. Modern work has been properly applied rather to deepening than embanking, except in those cases where the latter necessarily formed part of the work; Vermuden, and Kinderley and others, between 1721 and 1770, were the first who struck out the essentials of good drainage, viz., the efficient outfall cuts; it is fair, however, to remark that good banks must always precede good drains in newly embanked countries.

THE RIVER HUMBER.

We have not access to any complete engineering survey of the tides of the Humber; and can therefore only give the entire particulars of spring and neap tide at Grimsby; diurnal inequality appears to be strongly marked here. Humber tides are strong, and, like the Ouse, Severn, and Mersey, carry much silt, depositing it capriciously wherever an opportunity offers, and readily cutting out deep channels in the bed when tidal stream is diverted on any spot, from general or accidental causes. The great tidal flow of this river and its deep channels intersecting the delta of the Trent and other rivers of which the Humber is the Tidal Estuary, offer much facility for the effective drainage of the vast area of marsh lands bordering upon its ramifications; the silt deposited at ebb tide is also of great benefit in warping and fertilization.

TIDES OF THE HUMBER,

AT GREAT GRIMSBY.

TABLE SHEWING THE RISE AND FALL OF A SPRING & NEAP TIDE,

Together with the Tidal Range, and Semi-diurnal Inequality for three successive days of Spring and Neap Tides.

Datum Line 4 feet above Cill of 70 feet Lock.

SPRING TIDES.

Oct. 5, 1846. Time.	Hght.	TIDAL RANGE.							Tidal Range.		Semi-diurnal inequality.
		Date. 1846.	Moon's age at noon.	High Water.		Low Water.		High Water.			
				Time.	Height on Gauge.	Time.	Height on Gauge.	Time.	Height on Gauge.	a.m.	p.m.	
H. M. a.m.	H. W. ft. ins.		days.	H. M.	ft. ins.	H. M.	ft. ins.	H. M.	ft. ins.	ft. ins.	ft. ins.	ft. ins.
5 0	24 7	October 4th.....	14	5 0a.m.	23 4	11 10a.m.	1 9	5 0p.m.	22 4	21 7	20 7	1 0
5 30	24 0	" 5th.....	15	5 0	24 7	0 15p.m.	1 3	5 45	22 7	23 4	21 4	2 0
6 0	23 0	" 6th.....	16	5 45	24 6	0 30	0 0	6 20	22 1	24 6	22 1	2 5
6 30	21 6											
7 0	20 3											
7 30	18 6											
8 0	16 5											
8 30	13 9											
9 0	11 3											
9 30	8 9											
10 0	7 0											
10 30	4 9											
11 0	3 3											
11 30	2 0											
12 0 p.m.	1 4½ L. W.											
0 15	1 3											
1 0	2 6											
1 30	4 3											
2 0	6 3											
2 30	9 3											
3 0	12 2											
3 30	14 9											
4 0	17 4											
4 30	19 8											
5 0	21 6											
5 30	22 4 H. W.											
5 45	22 8											

NEAP TIDES.

Oct. 14, 1846. Time.	Hght.	TIDAL RANGE.							Tidal Range.		Semi-diurnal inequality.
		Date. 1846.	Moon's age at noon.	High Water.		Low Water.		High Water.			
				Time.	Height on Gauge.	Time.	Height on Gauge.	Time.	Height on Gauge.	a.m.	p.m.	
H. M. a.m.	L. W. ft. ins.		days.	H. M.	ft. ins.	H. M.	ft. ins.	H. M.	ft. ins.	ft. ins.	ft. ins.	ft. ins.
7 0	6 6	September 13th ..	23	11 1a.m.	17 8	5 0p.m.	7 10	11 30p.m.	18 3	9 10	10 5	0 7
7 30	6 9				Low Water.	High Water.		Low Water.				
8 0	7 3	October 14th.....	24	7 0	6 6	1 30	15 10	6 40	8 11	9 4	6 11	3 5
8 30	8 0	November 12th ..	25	6 30	7 4	0 30	16 7	6 30	8 7	9 3	8 0	1 3
9 0	8 9											
9 30	9 8											
10 0	10 8											
10 30	12 0											
11 0	13 0											
11 30	13 10											
12 0 p.m.	14 8											
0 30	15 4											
1 0	15 9 H. W.											
1 30	15 10											
2 0	15 9											
2 30	15 5											
3 0	14 10											
3 30	14 3											
4 0	13 3											
4 30	12 3											
5 0	11 1											
5 30	10 4											
6 0	9 6											
6 30	9 0 L. W.											
6 40	8 11											

THE RIVER TAY.

This river is subject to great floods, from the mountainous character of its source; below Perth it becomes a tidal estuary, in which vast quantities of material from the Grampians have been deposited.

Previously to 1835 the river between Perth and Newburgh was obstructed by sand banks and boulders. Great improvements were effected on this upper tidal portion, under direction of Messrs. Stevenson, of Edinburgh, who dredged out in this division 815,000 tons, between 1835 and 1841, at an expense of about £53,000.

In a report, made in 1845, by these gentlemen, to the conservators of the river, they describe the Tay as draining 2,283 square miles, and having a *mean* discharge at Perth of 218,158 cubic feet per minute*; about seven miles below that city, the Earn adds its volume, giving, by the same authority, a *mean* discharge of 54,959 cubic feet per minute.

The head of navigation at Perth is 23 miles from Dundee, and 32 from the German Ocean, but the tide extends to 2½ miles above Perth.

The extreme tides from neaps to springs:—

At Dundee, range from	7	to	18 feet.
At Newburgh, „ „	6.5	to	15 „
At Perth, „ „	6	to	13 „

The depth of water in the Frith ranges from 36 to 54 feet at high water, the bar having about 34 feet at spring tides. From Frisk point to Newburgh the river gradually shoals from 30 feet to 18 feet; and from Newburgh to Perth, from 18 to 15 feet at high water spring tides; the navigable breadth being scarcely ever less than 100 yards.

Previous to the commencement of Messrs. Stevenson's improvements, the river was impeded by fords and salmon weirs, or fishings, so that vessels drawing from 10 to 11 feet frequently missed even spring tides. The river was also obstructed by large boulders. The works executed were, in the words of the report:—

"*First.*—The fords, and many intermediate shallows, were deepened by steam dredging; and the system of harrowing, which was so successfully practised on the Mersey, was employed on some of the softer banks on the lower part of the river.

"*Second.*—The large detached boulders and fishing-cairns, which obstructed the passage of vessels, were removed by means of lighters, mounted with cranes, and by pontoons.

"*Third.*—Three subsidiary channels at Sleepless, Darry, and Balhepburn islands, were shut up by means of embankments formed of the produce of the dredging, so as to confine the whole of the water to the navigable channel.

"*Fourth.*—In some places the banks on each side of the river beyond low water mark, where much contracted, were excavated and removed, in order to equalize the currents, by allowing sufficient space for the free passage of the water.

"*Fifth.* — A great part of the dredged material was deposited along the banks of the river in a careful manner, so as to form new Fishing Beaches, to compensate for the removal of others."

The commercial effect of these improvements shew that in 1833, 12

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* According to this, the amount run off the surface would represent about 21.5 inches in the year. The ordinary summer run (July) of the Tay at Perth, amounts to 60,000 cubic feet per minute, or 26 cubic feet per minute per square mile, but in a dry autumn there is not above two-thirds of this quantity. High floods in the Tay have discharged, for more than twenty-four hours consecutively, as much as 660,000 cubic feet per minute, or 286 cubic feet per square mile, or nearly three-sixteenths of an inch in depth over the surface run off.

vessels of 100 to 144 tons and upwards, frequented the port; while in 1844 there were 37 vessels, from 100 to 400 tons, and the customs rose from £2,969 to £16,837.

We have given in a table at page 244 (from Messrs. Stevenson's report) the chief phenomena of the velocity of the tidal wave and fall of the river surface, which have a relation to each other in the inverse ratio of the square root of the rate of fall. For instance, between Newburgh and Perth the low water surface fall,

In 1833 was .467 feet per mile. Velocity of wave 301 feet per minute.
In 1844 ,, .233 ,, Velocity of wave 452 ,,

From this it results that the tide begins to flow now fifty minutes sooner at Perth than before the improvements.

The result of observations in 1833 and 1844, at Newburgh, shew that the duration of flood and ebb tides at that place are unchanged. The times are as follows:—

	H.	M.
Spring tides flow	4	20
,, ebb	7	20
Neap tides flow	4	30
,, ebb	6	45
At Perth, in 1833,—		
Spring tides flowed	2	20
,, ebbed	7	0
Neap tides flowed	3	15
,, ebbed	7	0
At Perth, in 1844,—		
Spring tides flowed	3	10
,, ebbed	7	10
Neap tides flowed	3	10
,, ebbed	7	0
Increase of duration flood at Perth	0	50
In 1833 the river ran at its natural level at spring tide	1	45
In 1844 it runs at its natural level at spring tide	1	0
Giving a decrease in the time of standing at low water, or in the absence of tidal influence at Perth, at spring tides, of	0	45

We have abstracted these facts at some length, because the Tay is a most striking instance of the advantages of expediting the tidal wave and flow, by the formation of a uniform passage, without any violent changes in the form of the channel itself, and at a comparatively moderate expense.

TIDES OF THE TAY.

RESULTS OF TIDAL OBSERVATIONS,

Made at various times between 1833 and 1844, by Messrs. Stevenson of Edinburgh, shewing the results of the improvements in the river, by dredging, &c.

Stations.	Distance.	1833 & 1834.		1842, 1843, and 1844.		Improvemat.	
		Diff. of H. W.	Vel. of Tidal Wave per Min.	Diff. of H. W.	Vel. of Tidal Wave per Min.	Time.	Velocity per Minute.
Between	Feet.	Mins	Feet.	Mins.	Feet.	Mins.	Feet.
Dundee and Balmerino.....	26,400	16	1,650	same as in the years 1833 and 1834			
Balmerino and Flisk Point	15,470	29	533.4				
Flisk Point and Balmbreich	10,771	26	414.3				
Balmbreich and Newburgh	18,058	53	340.7				
Newburgh (*a*) and Perth (*b*)	45,197	150	301.3	100	452	50	150.7
Dundee and Perth	115,896	274	422.9	224	517.4	50	94.5
Newburgh (*a*) and Carpon...	7,022	not observed in 1834		25	281.		
Carpon and Kinfauns.....	25,925			55	462.3		
Kinfauns and Perth (*b*).....	12,250			20	612.5		

LEVELS OF HIGH WATER SURFACE.

The levels of the surface of high water, at different stations, have been found to be unchanged, and the following results refer to the years 1833 and 1844.

Stations.	Distances.	Spring Tide, 1833 & 1844.			Neap Tide, 1833 & 1844.		
		Rise.	Fall.	Rate per Mile.	Rise.	Fall.	Rate per Mile.
Between	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
Flisk Point and Balmbreich	10,771	..	.42	.206	..	21	.103
Balmbreich and Newburgh	18,058	.62	..	.181	.50	..	.145
Newburgh and Perth.....	45,197	1.00	..	.117	1.00	..	.117

LEVELS OF LOW WATER SURFACE.

Stations.	Distances.	Spring Tide, 1833.		Spring Tide. 1844.	
		Rise.	Rate per Mile.	Rise.	Rate per Mile.
Between	Feet.	Feet.	Feet.	Feet.	Feet.
Flisk Point and Balmbreich ...	10,771	.33	.161	.33	.161
Balmbreich and Newburgh	18,058	2.66	1.304	2.66	1.304
Newburgh and Perth.....	45,197	4.00	.467	2.00	.233

Note.—The result of the observations in 1844, gives a depression on the level of low water mark of 2 feet, at Perth *tidal harbour*, the point to which Perth observations refer

THE RIVER TYNE.—Plate IX.

This river presented a great field for improvement, which is now being applied to it on an immense scale. The Commissioners of the Tyne are forming very extensive piers, with a view of concentrating tidal flow over the bar, and eventually forming a harbour of refuge; this work is under the advice of Messrs. Walker, Burges and Cooper.

Concurrently with these piers, the Commissioners are about to deal boldly with the river itself; this work is now commenced by Mr. Ure, their engineer, who has constructed an enormous dredging engine, adapted to run out into the seaway in order to execute effective dredging of the bar itself, as well as the other parts of the river; this is the kind of operation most adapted to the power of modern appliances, and it may be predicted that the results of thorough dredging at the bar will be not less beneficial than surprising.

Hitherto the River Tyne has suffered grievously from its bar, and also from being subject to great floods at the point where the tide meets, which in the course of ages have brought down heavy gravel deposits. These floods, from want of proper train and regularity of conservation, do great harm when they might be productive of good. The bar of the Tyne has a very serious effect on the general utility of the river; for it is literally a weir preventing the proper flow and ebb of the tidal waters, which are again further checked by the large expanse of Jarrow Slake within the river mouth (like the Burgh flats on the Waveney); these causes unite greatly in checking the concentration of tidal flow up stream. Immense docks have recently been completed at Hayhole and Jarrow, which will assist both by affording a better channel, and by the revenue created by them. The section of this river as it stood in 1850 exhibits manifest capability of improvement, especially if combined with cutting off some of the worst bends (a very costly work), which is proposed by the present engineer. This is shewn in plate IX., which also exhibits the surface slopes formed by high and low waters at different periods for a spring tide of May 2nd, and neap tide of April 2nd, 1850, as more particularly described in the tidal observations at pages 246-7. The facts arising out of these are given in pages 248-9, viz., velocity of tidal wave, slope of surface, and sectional area of the river. In a few years time, if the present style of works are persevered in, a careful set of similar experiments will shew most remarkable alterations for the better, as in the Thames and the Clyde.

In dealing with rivers or creeks of the character of the Tyne, it cannot be too strongly kept in view that the original form is caused mainly by geological dislocations, not materially by any action of the water. The natural action of flood waters in such small creeks, merely tends to fill up, and make shoals or sand banks, but not effectually to remove material; nor is this the work of a day, but of *very long periods* of time. It may be doubted whether any changes of river beds are great on the broad scale in any limited period of time, except in those rivers running in their own alluvium, and in this case, as with rivers having wide sands for their bed, the great apparent changes are generally only local. See plate XVI. as to the Ganges, where figs 2 and 3 exhibit a specimen of the sand-banks and wandering courses of that variable river.

TIDES OF THE TYNE.

TABLE OF THE RISE AND FALL OF THE TIDE,

At various points, taken simultaneously from the mouth of the river to Newburn, under the direction of J. M. Rendel, Esq., F.R.S.

Zero is the mark at Prior's Stone, being Low Water of May 31st, 1813.

SPRING TIDE, May 8th, 1850.

Time.	Prior's Stone.	Ballast Office.	How-don.	Bill Point.	Old Quay.	Els-wick.	Stella.	New-burn.
H. M.	Ft. Ins.	Ft. Ins	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.
		10 45 a.m.	11 18					
10 30 a.m.	0 10LW	1 3LW	1 10LW					
11 0 „	1 2	1 5	1 11					
11 30 „	2 1	2 0	2 11	12 15 p.m.				
12 0 „	3 2	3 3	3 11	3 2LW	12 45			
0 30 p.m.	4 6	4 6	4 2	3 5	3 4LW			
1 0 „	6 2	6 2	5 6	4 4	3 11	1 45 .		
1 30 „	8 0	7 9	7 1½	5 6	4 11	5 4LW		
2 0 „	9 10	9 6	8 9	7 3	6 4½	5 8		
2 30 „	11 2	10 10	10 3	9 0	8 1½	6 10	3 15	
3 0 „	12 2	12 0	11 6	10 7	9 7½	8 0½	3 0½LW	
3 30 „	12 9	12 8	12 5	11 9	10 11	9, 6	8 2	
4 0 „	13 2	13 2	13 0	12 8	12 0	10 10	9 0½	
4 30 „	13 2	13 0	13 4HW	13 1½	12 9	12 0	10 11	11 1LW
5 0 „	12 8	12 10	13 0	13 3HW	13 1	12 10½	11 5	12 3
5 30 „	11 10	12 3	12 2½	12 9	13 2	13 4½	13 6	13 6
6 0 „	10 11	11 3	11 1	12 2	12 9	13 2	13 7½	13 9
6 30 „	9 8	10 2	10 2½	11 5	12 0	12 6	12 10	13 0
7 0 „	8 0	9 0	9 6	10 6	11 2	11 9	12 1	12 3
7 30 „	6 4	7 6	8 2	9 6	10 3	11 0	11 5	11 9
8 0 „	4 10	6 0	7 0	8 5	9 4	10 3	10 9	11 3
8 30 „	3 7	4 8	5 10	7 6	8 6	9 6	10 2	11 1
9 0 „	2 7	3 7	4 9	6 8½	7 8	8 11	9 9	11 0½
9 30 „	1 8	2 7	3 10	6 0	7 0	8 3	9 3	
10 0 „	1 1	1 9	3 0	5 3	6 3	7 9	8 11	
10 30 „	0 11LW	1 5	2 5	4 9	5 7½	7 5	8 8	
11 0 „	..	1 2LW	1 11	4 3	5 0	7 0	8 6	
11 30 „	..	..	1 9LW	3 9	4 6	6 7	8 4	
12 0 „	..	..	..	3 5	4 0	6 3	8 3	
0 30 a.m.	..	..	..	3 2LW	3 7	5 11	8 2	
1 0 „	..	..	..	..	3 5LW	5 7½	8 1½	
1 30 „	..	..	..	..	..	5 5½	8 1	
1 50 „	..	..	..	..	..	5 4½LW	8 0½LW	
4 15 „	..	13 3HW						
5 15 „	..	..	..	..	13 4HW			
5 45 „	.	..	..	..	..	..	13 9HW	13 10HW

TIDES OF THE TYNE.

TABLE OF THE RISE AND FALL OF THE TIDE,

At various points, taken simultaneously from the mouth of the river to Newburn, under the direction of J. M. Rendel, Esq., F.R.S.

Zero is the mark at Prior's Stone, being Low Water of May 31st, 1813.

NEAP TIDE, April 2nd, 1849.

Time.	Prior's Stone.	Ballast Office.	Howdon.	Bill Point.	Old Quay.	Elswick.	Stella.	Newburn.
H. M.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.
4 45 a.m.	3 9	4 0	4 5					
5 0 „	3 8LW	3 11LW	4 3					
5 30 „	3 10	3 11½	4 0½LW					
6 0 „	4 2	4 2	4 1½	4 8½				
6 30 „	4 6	4 7	4 6½	4 9				
7 0 „	5 0	5 4	5 1	5 1	5 1½LW			
7 30 „	5 9	6 0	5 8½	5 6	5 3			
8 0 „	6 8	7 0	6 7½	6 2	6 0	7 2LW		
8 30 „	7 7	7 10	7 6	7 1	6 11	7 3		
9 0 „	8 6	8 10	8 5½	8 0	7 8½	7 8	9 45	
9 30 „	..	9 8	9 3	9 0	8 7	8 5½	9 9LW	
10 0 „	..	10 4	10 2	9 10	9 4	9 2	9 10	
10 30 „	11 2HW	10 10	10 8½	10 7	10 3	9 11	10 4	11 18
11 0 „	..	11 2HW	11 1½	11 2	10 11	10 8	11 0	12 7
11 30 „	..	11 2	11 5HW	11 6½	11 5	11 4	11 7	12 7½
12 0 „	..	11 0	11 2½	11 8½HW	11 7	11 10	12 0	12 10
0 30 p.m.	..	10 7	10 10	11 7	11 8	11 10HW	12 1	12 11HW
1 0 „	..	10 0	10 4	11 0	11 2	11 7	11 10½	12 10
1 30 „	..	9 2	9 6	10 4	10 7	11 1	11 7	12 9
2 0 „	..	8 3	8 8	9 7	10 0	10 7	11 3	12 8
2 30 „	..	7 4	7 10	8 10	9 3½	10 1	10 11	12 6½
3 0 „	..	6 6	6 11½	8 2	8 7½	9 7	10 7	12 5½
3 30 „	4 11	5 6	6 1	7 6	8 0	9 1	10 3½	12 4
4 0 „	4 2	4 10	5 4	6 10	7 5	8 8	10 0	12 3
4 30 „	3 6	3 10	4 8	6 3	6 11	8 3½	9 10½	12 2½
5 0 „	2 11	3 5	4 1	5 9	6 4	7 11	9 8½	
5 30 „	2 8LW	3 0	3 7½	5 3	5 9	7 7	9 7½	
6 0 „	..	2 11LW	3 3½	4 10	5 5	7 3½	9 6½	
6 30 „	..	..	3 2LW	4 4	5 0	7 1	9 5½	
7 0 „	..	..	..	4 2	4 7½	6 11	9 5LW	
7 30 „	..	..	..	..	4 4	6 9		
8 0 „	..	..	..	..	4 2LW	6 7		
8 30 „	..	..	..	..	..	6 6LW		
12 15 p.m.	..	..	..	..	11 8½HW	..	12 1½HW	
4 45 „	..	..	..	..	..	..	..	12 2LW
7 15 „	..	..	..	4 1LW				

TIDES OF THE TYNE.

VELOCITIES OF THE HEAD AND FOOT OF A TIDAL WAVE,

At a Spring and Neap Tide, from the mouth of the river to Newburn.

From observations taken under the direction of J. M. Rendel, Esq., F.R.S.

SPRING TIDE, May 8th, 1850, one day after Full Moon.

Names of Stations.	Distances.	Tidal Range.	Interval of Passage of Foot of Wave	Interval of Passage of Head of Wave	Rate per Minute. Foot.	Rate per Minute. Head.
Between	Feet.	Ft. In.	Mins.	Mins.	Ft.	Ft.
Tynemouth Haven and Prior's Stone...	2,640	12 7 T H	..	15	..	176.0
Prior's Stone and Ballast Office	3,894	12 4 P S	15	15	259.6	259.6
Ballast Office and Howdon.....	13,200	12 0 B O	30	15	440.0	880.0
Howdon and Bill Point	20,064	11 6 H	60	25	334.4	802.6
Bill Point and Old Quay.....	15,576	10 1 B P	30	20	519.2	778.8
Old Quay and Elswick	12,804	10 0 O Q	60	15	213.4	853.6
Elswick and Stella	18,942	8 0½ E	90	..	210.5	..
Stella and Newburn	7,524	5 8½ St.	75	15	100.3	501.6
Tynemouth and Newburn	94,644	2 9 N	360	120	262.9	788.7

NEAP TIDE, April 2nd, 1849.

Names of Stations.	Distances.	Tidal Range.	Interval of Passage of Foot of Wave	Interval of Passage of Head of Wave	Rate per Minute. Foot.	Rate per Minute. Head.
Between	Feet.	Ft. In.	Mins.	Mins.	Ft.	Ft.
Tynemouth Haven and Prior's Stone..	2,640	7 6 T H	15	15	176.0	176.0
Prior's Stone and Ballast Office	3,894	7 6 P S	15	15	259.6	259.6
Ballast Office and Howdon.....	13,200	7 3 B O	30	30	440.0	440.0
Howdon and Bill Point	20,064	7 4½ H	40	30	501.5	668.8
Bill Point and Old Quay.....	15,576	7 0 B P	30	15	519.2	1038.4
Old Quay and Elswick	12,804	6 7 O Q	80	..	160.5	..
Elswick and Stella	18,942	4 8 E	90	..	210.5	..
Stella and Newburn	7,524	2 4 St.	90	15	83.6	501.6
Tynemouth and Newburn	94,644	0 8½ N	390	120	242.7	788.7

TIDES OF THE TYNE.

INCLINATION OF WATER SURFACE

At the times of High and Low Water, at Tynemouth Haven and at Newburn, with Fall of River Bed, Sectional Area, &c.

Zero is the Mark at Prior's Stone, being Low Water of May 31st, 1813.

SPRING TIDE, May 8th, 1850.

When High and Low Water at Tynemouth Haven.	Distances.	Height on Gauge.		Average Inclination per Mile.		Area, &c. at High Water.		
		At H. W.	At L. W.	At H.W. Fall.	At L.W. Rise.	Area.	Greatest Wdth.	Greatest Dpth.
	Feet.	Ft. In.	Ft. In.	Feet.	Feet.	Sq. Ft.	Feet.	Feet.
Tynemouth Haven...	..	13 4	0 8					
Prior's Stone.....	2,640	13 2	0 11	.333	.500			
Ballast Office	3,894	13 2	1 5	..	.686			
Howdon	13,200	13 0	2 5	.064	.400	24,500	1,550	25
Bill Point	20,064	12 8	4 9	.087	.613	10,770	750	25
Old Quay	15,576	12 0	5 7½	.230	.295	6,935	363	22
Mansion House	1,386	11 11	5 11	.316	1.115	7,000	560	13
Elswick	11,418	10 10	7 5	.500	.696	6,270	660	13
Stella	18,942	9 0½	8 8	.500	.349	1,800	300	13
Newburn	7,524	11 1	11 0½	Rise. 1.436	1.670	1,300	320	5
Average.....	94,644	..	..	..	.579			
		Average fall to Stella		.259				

When High and Low Water at Newburn.	Distances.	Height on Gauge.		Average Inclination per Mile.		Area, &c. at Low Water.		
		At H. W.	At L. W.	At H.W. Fall.	At L.W. Rise.	Area.	Greatest Wdth.	Greatest Dpth.
	Feet.	Ft. In.	Ft. In.	Feet.	Feet.	Sq. Ft.	Feet.	Feet.
Newburn	..	13 9	11 0½	..	..	100	200	2.25
Stella	7,524	13 7½	9 9	.084	.905	360	150	7.33
Elswick	18,942	13 2	8 11	.128	.232	600	300	5.0
Mansion House	11,418	12 11	7 11	.115	.463	1,000	530	3.25
Old Quay	1,386	12 9	7 8	.615	.961	2,770	363	11.0
Bill Point	15,576	12 2	6 8½	.196	.326	2,874	400	15.0
Howdon	20,064	11 1	4 9	.284	.516	5,500	1,100	13.50
Ballast Office	13,200	11 3	3 7	Rise. .064	.464			
Prior's Stone.....	3,894	10 11	2 7	Fall. .452	1.356			
Tynemouth Haven...	2,640	10 6	2 0	.833	1.166			
Average.....	94,644	..	..	.181	.504			

THE RIVER CLYDE.—Plate XI.

This river has had large sums of money spent in deepening its bed and regulating its banks above Dumbarton. These works have been similar to those described on the Tay, and have been only greater and more effective, inasmuch as the outlay has been on a prodigious scale and commensurate with the great commerce of Glasgow and the surrounding mining districts.

High water at springs is now alleged to rise nearly two feet higher than before the improvements, and the draft of water is increased from four feet to more than twenty feet, while the time of high water at Glasgow is accelerated twenty minutes, and the time of young flood far more. At pages 251-2-3, are the chief phenomena of the river, placed in a similar manner to those of the Tay.

In comparing it with the Tay, we must regard the Clyde above Bowling as now resembling a great tidal canal; the Tay from a mile below Perth being rather an estuary, opening out gradually with wide and flat sandy shores at low water. The Tay is also subject to far more rapid and greater volume of floods, by which much larger quantities of sand are transported, and deposited over the estuary immediately at its junction with the tide.

Plate XI. is a section of this river, shewing its state from A.D. 1758 to 1861. The tabulated tidal observations are for 1840, since which the dredging has been continuous. The material removed has been greatly used to regulate the channel and fill up large useless shoals. Training walls of stone at a slope of about 2 to 1 have also been adopted on this river; they contribute much to the efficiency of scour and convenience of navigation.

At page 210 we have given Mr. Scott Russell's experiments on the level of the tide and velocity of the wave which were made in 1836; the position of the stations named can be ascertained on the section of the River Clyde at or about the period of the experiments.

The editor of the *Builder* remarks that—"Of the Clyde it is impossible to speak in other language than that of admiration. It is but the fourth river in Scotland in volume of fresh water, and the third in length; inferior to the Forth or Tay in Highland scenery; and to the Tweed in pastoral beauty; but it is superior to all of them in utility, in artificial improvement, in manufactures, in commerce, and in the triumphs of mechanical genius. The improvements on this river have, we must say, been conducted on a scale of unusual magnificence. About a century ago its depths at the point where the Kelvin discharges into its channel was only 18 inches at low water, and 44 inches at high water. Its course, far below Dumbarton, abounded in shallow lagoons, interspersed with low islets and marshy ground. By judicious engineering operations, spread over a series of years, accompanied with an enormous expenditure of capital, it is now as navigable as the Thames. In fact, by dint of dredging, cutting, excavating, and embanking, to the tune of about a million and a-half sterling, the navigable depth of the river has been increased, within the last 50 or 60 years, from 3 feet to 20 feet, and the revenue from £3,000 to £90,000 per annum. The Bromielaw harbour is at this moment practically nothing less than half-a-mile of excellent docks—we need not say how crowded; and the contrast is indeed great between the small fishing sloops and Virginia traders which once unloaded their treasures on the same spot, and the gigantic iron steamer and the merchantman of 2,000 tons, which now constitute the honour and glory of the Clyde."

TIDES OF THE CLYDE.

TABLE OF TIDAL OBSERVATIONS,

Taken simultaneously between Port Glasgow and Glasgow, in 1840; shewing also the acceleration in the time of high water.

Datum, 20 feet below coping of South Quay Wall, near Glasgow Bridge.

SPRING TIDE, 20th March, 1840.

Time.	Port Glsgow	Bowling.	Clyde Bank.	Glsgow
H. M.	Ft. In.	Ft. In.	Ft. In.	Ft. In.
A.M. 8 0	1 8			
9 0	3 9	2 10		
10 0	5 0	4 3	3 8	3 OLW
11 0	6 9½	5 4	4 9	4 8
12 0	8 8½	6 11	6 1½	6 0½
P.M. 1 0	10 3½	9 2½	7 10	7 9
2 0	10 1	10 10	10 0½	9 10½
3 10	7 11	9 5	10 7	11 1½HW
4 10	5 4	8 1	9 4	9 8½
5 10	3 4	6 10	8 0	8 3
6 10	1 4	5 7½	6 8½	7 0
7 10	0 2½	4 2	5 7	5 10½
8 10	..	2 11	4 5½	4 9
9 10	..	..	3 4	3 9
A.M. 7 10	0 2¾LW			
8 38	..	2 4LW		
9 30	..	..	3 1LW	
P.M. 1 25	10 5½HW			
2 5	..	10 10HW		
2 50	..	..	10 10HW	

NEAP TIDE, 27th March, 1840.

Stations.	High W.	Low W.	Range.	Remarks
	Ft. In.	Ft. In.	Ft. In.	
Pt. Glasgow	7 5	2 4	5 1	H. W. at Glasgow 6″ higher than Port Glasgow.
Bowling.....	7 9	2 6	5 3	
Clyde Bank	7 11	2 8	5 3	L. W. at Glasgow 3″ higher than Port Glasgow.
Glasgow	7 11	2 7	5 4	

High Water of Spring Tide,

24th December, 1839,

With Fresh Wind, West.

	Ft. In.		Ft. In.
Port Glasgow...	14 5	Clyde Bank.....	15 6
Bowling	15 0	Glasgow	16 2

Note.—High Water at Glasgow 1.9″ higher than at Port Glasgow.

	H. M.
Note.—In 1824, H. W. at Glasgow later than at Port Glasgow.....	2 05
In 1840, ditto	1 45
Acceleration in 16 years.....	0 20

Velocities of Flood and Ebb Streams.

STATIONS.	Rate per M. Fld.	Ebb.
Between	Feet	Feet.
Glasgow and Newshot Isle	38.5	78.8
Newshot I. and Dumbarton Castle	80.1	139.3

VELOCITIES OF THE HEAD AND FOOT OF A TIDAL WAVE,

Between Port Glasgow and Glasgow.

SPRING TIDE, 20th, March, 1840.

STATIONS.	Distances Apart.	Tidal Range	Interval of Passage of Foot of Wave.	Interval of Passage of Head of Wave.	Rate per Minute. Foot.	Rate per Minute. Head.	Width of River
Between	Feet.	Ft. In.	Mins.	Mins.	Feet.	Feet.	Feet.
Port Glasgow and Bowling	43,230	10 2¾PtG	88	40	491.2	1080.7	550 B
Bowling and Clyde Bank	26,290	8 6B	52	45	505.6	584.2	250 CB
Clyde Bank and Glasgow	28,820	7 9CB	30	20	960.6	1,441	420 G
Port Glasgow & Glasgow	98,340	8 1½ G	170	105	578.5	936.6	

TIDES OF THE CLYDE.

INCLINATION OF WATER SURFACE,

At the times of High and Low Water at Port Glasgow and Glasgow, at the Spring Tide of March 20th, 1840.

Datum 20 feet below Coping of South Quay Wall.

WHEN HIGH WATER AT PORT GLASGOW - - 1.25 p.m.
AND LOW WATER „ „ - - 7.20 „

STATIONS.	Distances.	Height on Gauge. At 1.0 p.m. or 25 minutes before H. W.	Height on Gauge. At 7.10 p.m. or 10 minutes before L. W.	Inclin. per Mile. At 1.0 p.m. or 25 minutes before H. W FALL.	Inclin. per Mile. At 7.10 p.m. or 10 minutes before L. W RISE.
	Feet.	Ft. In.	Ft. In.	Feet.	Feet.
Port Glasgow	..	10. 3½	0 2½	..	..
Bowling	43,230	9. 2½	4 2	0.132	0.483
Clyde Bank	26,290	7.10	5 7	0.279	0.285
Glasgow	28,820	7. 9	5 10½	0.014	0.053
Average	98,340			0.136	0.304

WHEN HIGH WATER AT GLASGOW - - - - - 3.10 p.m.
AND LOW WATER „ „ - - - - -10. 0 a.m.

STATIONS.	Distances.	Height on Gauge. At High Water. FALL.	Height on Gauge. At Low Water. RISE.	Inclin. per Mile. At High Water. FALL.	Inclin. per Mile. At Low Water. RISE.
	Feet.	Ft. In.	Ft. In.	Feet.	Feet.
Glasgow	..	11 1½	3 0	..	..
Clyde Bank	28,820	10 7	3 8	0.099	0.122
Bowling	26,290	9 5	4 3	0.233	0.116
Port Glasgow	43,230	7 11	5 0	0.183	0.092
Average	98,340			0.171	0.107

SECTIONAL AREAS.

Spring Tide, March 20th, 1840.	At High Water. Area.	At High Water. Greatest Width.	At High Water. Greatest Depth	At Low Water. Area.	At Low Water. Greatest Width.	At Low Water. Greatest Depth.
	Sq. Feet.	Feet.	Ft. Ins.	Sq. Feet.	Feet.	Ft. Ins.
Glasgow	3,148	198	18. 3	1,549	191	10 0
Clyde Bank	4,605	273	17.0	1,911	245	9. 0
Neap Tide, March 27th, 1840.						
Glasgow	2,524	195	15. 7	1,494	191	10. 3
Clyde Bank	3,186	255	14.6	1,840	245	9. 3

TIDES OF THE CLYDE.

MEAN TIDAL RANGE AND DURATION OF FLOOD AND EBB STREAMS,

For six Spring and six Neap Tides, from observations by W. Bald, Esq.

Spring Tides.	Glasgow.	Clyde Bank.	Bowling.	Port Glasgow.
	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.
Tidal Range	8 4	8 0	8 9	10 5
	H. M.	H. M.	H. M.	H. M.
Duration of Flood	5 10	5 15	5 24	6 6
„ Ebb	7 13	7 6	6 56	6 1
Neap Tides.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.
Tidal Range	6 3	5 10	5 11	6 1
	H. M.	H. M.	H. M.	H. M.
Duration of Flood	5 14	5 43	5 52	6 26
„ Ebb	7 16	7 1	6 37	5 59

MEAN VELOCITIES OF FLOOD AND EBB STREAMS.

Station opposite.	Distance below Glasgow Bridge.	Velocity of Flood per Minute.	Velocity of Ebb per Minute.
	Feet.	Feet.	Feet.
Dumbarton Castle	72,000	58.75	144.53
Dunglass Castle	59,500	92.73	145.71
Donald's Quay	52,000	114.43	147.13
Rushalee Pier	45,000	54.53	120.00
Centre of Newshot Isle	39,000	70.00	150.00
Average below Newshot Isle	..	**78.10**	**141.48**
1,000 yards below mouth of the Cart	31,000	60.00	100.00
Scotstoun House	24,000	26.66	85.70
200 yards below Crawford's Quay	15,000	50.00	75.00
600 yards above the mouth of the Kelvin	9,500	17.63	54.53
Average above Newshot Isle	..	**33.56**	**78.80**

During high floods, immediately below Glasgow Bridge, Mr. Bald found the Ebb Stream run at the rate of 256.6 feet per minute; and in the narrow parts of the river, at the rate of 321.4 feet per minute. This was at the water's surface, in the middle of the river.

THE RIVER MERSEY ESTUARY.—Plate VI.

The sea approach of this river is occupied by an immense area of half-tide sand banks, with channels of a great variety of character, affording from 6 to 12 feet depth at low water of spring tides. These banks are, to a great extent, quicksand, so that they change with every great exciting cause, creating a perpetual source of anxiety to those on whom devolves the duty of keeping them open for the great commerce of the manufacturing districts. Once within the headlands of Formby Point and New Brighton, the channel becomes deep, owing to its confinement between the fixed shores of the towns of Liverpool and Birkenhead; this channel is maintained by the great volume of waters ebbing out of, and flowing into, the extensive and wide area of the estuary, occupying twelve miles in length, between Toxteth Park and Frodsham.

The comparative widths of the Mersey at these points, will be seen by the cross sections in plate VI.; the velocity of the tide way at the narrow passage is very great, but directly the river widens out above Liverpool, banks are formed with capricious channels, in character very much like the sands at the bar. They are, however, much higher, and therefore dry at a much earlier period of the tide, and the low water channels are merely sufficient to carry the small upland waters of the river Mersey (about 2,600 square miles), their course through the sand-banks altering probably in proportion to the varying condition of the elements and climate. The sands of the Mersey owe their origin to two causes; viz., the mill-stone grits of the mountain at the sources, and the disintegration of the local rocks which girt the shores of the estuary, and are formed of friable sandstone; to the latter rocks probably the great bulk of the sands are due. The vast body of tidal water passing over the sea banks and bar, offers a powerful check on the counter effect of winds and waves of this stormy sea.

We have given, in plate VI., the form of tidal wave, from observations taken with extreme accuracy, in the parliamentary contest for the Birkenhead Docks. In the diagram, the growing up of the tidal wave, at the narrow part opposite Liverpool, the faltering again at the wide expanse between Eastham and Ellesmere Port, and the heading up again when narrowing at Runcorn, is shewn very strikingly. The great rise and volume of tide, and straight even sides not too far within the mouth, are the safeguards to maintenance of the port of Liverpool; the ample dock space, and cheapness of construction from the rock foundation, and tidal ebbing off, give the great pre-eminence of Liverpool as a port.

THE RIVER DEE ESTUARY,

In form, is strikingly the reverse of Liverpool; an injudicious mode of enclosure, unaccompanied by proper dredgings, has rendered useless what might have been a great improvement of its upper course; while the want of a proper application of capital lower down has permitted evils to gather strength.

The sand-banks of the estuary are most enormous, and they stand very high and dry at low water; there is also the want of a great natural channel inside, to give direction and effect to the currents; we are, however, of opinion that a sum of money, boldly spent, would effect a vast revolution in the navigation of the Dee, and with great benefit; for Chester is well placed for commercial intercourse with the mining districts and potteries. The sources of the Dee are far more extensive, and the floods greater than those of the Mersey; the result is evident in the greater deposit of sands, and difficulty of maintaining a sea passage.

TIDES OF THE MERSEY.

TABLE OF THE RISE AND FALL OF THE TIDE

At various points, taken simultaneously from the mouth of the river at Formby Point to the head of the tide at Warrington; from Mr. Rendel's experiments in the summer of 1844. Datum line 6 feet below Old Dock Cill, or 10.75 feet below the Ordnance half-tide datum.

SPRING TIDES, June 3rd, 1844.

TIME.	Formby Point.	New Brighton	Prince's Dock, Livrpool.	Ellesmere Port.	Duke's Dock, Runcorn.	Fiddlers' Ferry.	Warrington Bridge.
Distance.		42,240 ft.	10,560 ft.	47,520 ft.	35,200 ft.	28,160 ft.	27,400 ft.
H. M.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.
7 0 a.m.	— 3 10						
7 30 „	— 2 9	— 4 2	— 4 5				
8 0 „	— 0 10	— 3 2	— 3 5				
8 30 „	1 10	— 0 8	— 0 10				
9 0 „	5 6	3 6	2 10				
9 30 „	9 9	8 2	7 6				
10 0 „	14 0	12 7	11 9	6 4			
10 30 „	17 6	16 5	15 1½	10 7			
11 0 „	20 4	19 2	18 0	15 0	10 7		
11 30 „	22 2	21 5	20 6	18 3	16 9		
12 0 „	23 3	22 8	22 2	21 2	20 8		
0 30 p.m.	23 4	23 0	23 4	23 5	23 1	17 6	
1 0 „	22 6	22 8	23 7	24 7	24 11	22 6	18 1
1 30 „	21 2	21 4	22 7	24 2	25 4	24 9	18 3
2 0 „	19 4	19 6	20 7	22 9	24 1	25 2	23 0
2 30 „	16 11	16 8	17 7	20 11	22 3	24 0	25 9
3 0 „	14 0	13 9	14 7	18 3	20 0	22 6	23 10
3 30 „	10 11	11 0	11 10	15 9	18 3	21 8	22 8
4 0 „	8 2	8 4	9 4	13 4	16 3	20 8	21 10
4 30 „	5 4	5 10	6 10	10 7	14 5	19 10	21 1
5 0 „	2 9	3 8	4 4	8 6	13 1	19 4	20 8
5 30 „	0 9	1 7	2 0	7 2	12 3	18 10	20 2
6 0 „	— 0 10	0 0	0 4	6 7 LW	11 6	18 7	19 9
6 30 „	— 2 0	— 1 5	— 1 3	....	10 11	18 2	19 6
7 0 „	— 2 7	— 2 4	— 2 8	....	10 7	17 10	19 3
7 30 „	....	— 3 6	— 3 6	....	10 4	17 6	19 0

TIDES OF THE MERSEY.

TABLE OF THE RISE AND FALL OF THE TIDE

At various points, taken simultaneously from the mouth of the river at Formby Point to the head of the tide at Warrington; from Mr. Rendel's experiments in the summer of 1844. Datum line 6 feet below Old Dock Cill, or 10.75 feet below the Ordnance half-tide datum.

NEAP TIDES, June 10th, 1844.

TIME.	Formby Point.	New Brighton	Prince's Dock, Livrpool.	Ellesmere Port.	Duke's Dock, Runcorn.	Fiddlers' Ferry.	Warrington Bridge.
Distance.		42,240 ft.	10,560 ft.	47,520 ft.	35,200 ft.	28,160 ft.	27,400 ft.
H. M.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.
1 30 p.m.	3 3	2 6	2 9	1 11			
2 0 „	4 0	3 1	3 1	2 3			
2 30 „	5 5	4 0	4 1	3 0			
3 0 „	6 8	5 5	5 5	4 2			
3 30 „	8 4	7 3	7 3	*5 9			
4 0 „	10 2	9 4	9 3	7 2			
4 30 „	12 3	11 6	11 4	9 7	8 8		
5 0 „	14 3	13 6	13 4	11 10	8 9		
5 30 „	15 6	15 2	15 0	13 8	10 10		
6 0 „	16 10	16 3	16 3	15 5	13 6		
6 30 „	17 7	17 2	17 4	16 7	15 10		
7 0 „	17 9	17 7	18 0	17 7	17 4	16 1	
7 30 „	17 7	17 7	18 0	18 4	18 5	16 2	
8 0 „	16 11	16 10	17 6	18 3 (18 7 H.W.)	19 0	16 10	
8 30 „	15 9	15 11	16 4	17 5	18 6	18 3	18 1
9 0 „	14 9	14 4	15 1	16 2	17 5	18 10	18 1
9 30 „	13 2	12 9	13 6	14 4	16 4	18 2	18 5
10 0 „	12 3	11 0	11 6	12 8	15 2	17 9	18 9
10 30 „	9 9	9 5	10 0	10 9	13 10	17 4	18 8
11 0 „	8 3	7 11	8 5	9 1	12 9	17 1	18 6
11 30 „	6 3	6 4	6 11	7 9	12 0	16 10	18 5
12 0 „	5 4	5 0	5 6	6 8	11 3	16 8	18 4
0 30 a.m.	4 4	3 10	4 3	*4 6	10 9	16 7	18 2
1 0 „	3 7	2 10	3 4	3 0	10 3	16 4½	18 1½
1 30 „	3 1 LW	2 6 LW	2 9 LW	2 0	9 4	16 3	18 1½

* Below these points the Ellesmere tide is taken at Pool Hall Deep, about a mile below where there is a full range at Neap Tides.

TIDES OF THE MERSEY.

TABLE OF VELOCITIES OF THE HEAD AND FOOT OF TIDAL WAVE,

From the mouth to the head of the Tide at Warrington, at a Spring and Neap Tide.

Section of River from Prince's Dock to Seacombe.

	Area. Sq. Ft.		Width. Ft.	Depth. Ft.		Area. Sq. Ft.		Width. Ft.	Depth. Ft.
L.W.S.T.	114,546	...	3,214	× 50	H.W.N.T.	182,771	...	3,544	× 70
L.W.N.T.	138,415	...	3,300	× 57	H.W.S.T.	208,579	...	3,544	× 77

SPRING TIDE, June 3rd, 1844.

Names of Stations.	Distance apart.	Tidal Rnge	Interval of Passage OF		Rate per Minute of Tidal Wave.		
			Foot of Wave	Head of Wave	Foot of Wave.	Head of Wave.	Flood Stream
Between	Feet.	Feet.	Min.	Min.	Feet.	Feet.	Feet.
Formby Point and New Brighton...	42,240	27.5	50	20	845	2,112	
New Brighton and Princes Dock ...	10,560	27.2	6	10	1,760	1,056	401.4
Princes Dock and Ellesmere	47,520	28.0	140	20	340	2,376	336.6
Ellesmere and Runcorn	35,200	18.3	50	14	704	2,514	
Runcorn and Fiddler's Ferry	28,160	14.9	85	26	331	1,084	
Fiddler's Ferry and Warrington...	27,400	7.8	66	40	415	685	
Formby Point and Warrington	191,080	7.8	397	130	481	1,470	

NEAP TIDE, June 10th, 1844.

Names of Stations.	Distance apart.	Tidal Rnge	Interval of Passage OF		Rate per Minute of Tidal Wave.		
			Foot of Wave	Head of Wave	Foot of Wave.	Head of Wave.	Flood Stream
Between	Feet.	Feet.	Min.	Min.	Feet.	Feet.	Feet.
Formby Point and New Brighton...	42,240	14.5	..	20	..	2,112	
New Brighton and Princes Dock ...	10,560	15.1	25	20	422	528	
Princes Dock and Ellesmere	47,520	15.3	..	35	..	1,358	
Ellesmere and Runcorn	35,200	16.8	190	15	185	2,347	
Runcorn and Fiddler's Ferry.....	28,160	10.4	150	54	188	525	
Fiddler's Ferry and Warrington ...	27,400	1.8	95	46	288	595	
Formby Point and Warrington	191,080	0.8	460	190	415	1,006	

TIDES OF THE DEE.

TABLE OF PHENOMENA BETWEEN GREENFIELD AND CHESTER,

Taken from Minutes of Admiralty inquiry at Chester, in 1849.

The zero of heights is L.W.S.T. opposite Greenfield, or 22.75 below zero of Chester standard, being about 13.5 feet below mean half-tide level at Liverpool.

FORCED SPRING TIDE,

With Westerly Gale.

FEBRUARY 6th, 1849.

Time.	Flint.	Connah's Quay.	Sandy Croft.	Chester
H. M.	Ft. In.	Ft. In.	Ft. In.	Ft. In.
	9 9LW			
9 0a.m.	11 0			
9 15 „	13 0			
9 30 „	15 10			
9 45 „	18 3			
		14 3LW		
10 0 „	20 6	14 6		
10 15 „	22 0	17 0		
10 30 „	23 4	19 8	16 0LW	
10 45 „	25 0	23 10	20 0	
11 0 „	26 4	24 10	22 9	17 9LW
11 15 „	27 10	26 7	24 7	20 6
11 30 „	29 5	28 3	26 8	22 9
	29 11HW			
11 45 „	29 6	30 0	28 9	27 4
		30 9HW		
12 0 „	29 0	30 6	31 3HW	30 9
0 15p.m.	28 3	29 6	31 0	31 5HW
0 30 „	27 6	29 0	30 0	31 0
0 45 „	26 4	28 1	29 4	30 5
1 0 „	25 3	27 3	28 4	29 7
1 15 „	24 3	26 4	27 6	29 0
1 30 „	23 4	25 5	26 10	28 1
1 45 „	22 4	24 6	25 10	27 4
2 0 „	21 3	23 7	25 0	26 8
2 15 „	20 0	22 7	24 6	26 0
2 30 „	19 0	21 6	23 4	25 2
2 45 „	17 8	20 6	22 9	24 5
3 0 „	16 7	19 8	21 9	23 10
3 15 „	15 7	18 11	20 10	23 2
3 30 „	14 7	18 0	20 4	22 6
3 45 „	14 0	17 6	19 9	22 0

SUMMER LOW WATER.

Stations.	Length	Fall per Mile.
Between	Feet.	Feet.
Greenfield and Pentre Rock	30,095	1.84
Pentre Rock and Con. Quay	15,575	1.42
Con. Quay and Sandy Croft	17,160	.31
Sandy Croft and Saltney..	17,250	.75
Saltney and Chester.....	7,040	.21

VELOCITY OF HEAD AND FOOT OF TIDAL WAVE,

From Flint to Chester.

Stations. Between	Length	Tidal Range	Interval of Passage of Foot of Wave.	Interval of Passage of Head of Wave.	Rate per Minute. Foot.	Rate per Minute. Head.
	Feet.	Ft. Ins.	Mins.	Mins.	Feet.	Feet.
Flint and Pentre Rock	4,925	20. 2	20	5	246. 2	985
Pentre Rock and Connah's Quay	15,575	18. 10	45	10	346	1557.5
Connah's Quay and Sandy Croft	17,160	16.6	30	9	572	1906.6
Sandy Croft and Saltney	17,250	15.38	20	8	862. 5	2156. 2
Saltney and Chester	7,040	13.8	10	4	704	1760
Flint and Chester	61,950	13.8 C	125	36	495.6	1720.8

AUGUST 6th 1849.	Greenfield.	Flint.	Pentre Rock.	Connah's Quay.	Sandy Croft.	Saltny.	Chester
	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.	Ft. In.
High Water, Ord. Sp. Tde.	27 6	27 7	27 8	28 8	29 4	29 7	29 8
Low Water „ „ „	0 0	9 1	10 6	14 2	15 5	17 9	18 1
Tidal Range „ „ „	27 6	18 6	17 2	14 6	13 11	11 10	11 7

THE RIVER SEVERN AND ITS ESTUARY.—Plate VII.

The river Severn was surveyed in 1849 by the late Captain Beechey, F.R.S., under orders from the Admiralty. A short statement accompanies his elaborate maps, and from these documents we have compiled the information tabulated in the sequel. Captain Beechey's labours are here condensed into a form that will be best understood by a careful examination of the tables. The phenomena of the bore are shown to fluctuate in the inverse ratio of the velocity of the tidal wave, and in connexion with this, it will be observed that the fall of the Severn *increases* as it approaches the sea. With this fact the cause of the bore is closely connected. As we have before hinted in the case of the Ouse at King's Lynn, the surface fall generally decreases in approaching to the tide way, in the best form of river estuaries.

Low water at spring tides below Lidney is (as ordinarily) lower than at neaps; but above Lidney the reverse takes place;* this Captain Beechey thinks is occasioned by the waves throwing more water into the river than can escape at spring tides. The form of high and low water springs and neaps is given in the tables; it will be seen that the maximum height of springs is between Framilode and Rosemary, dropping downwards to Haw Bridge, after which it ascends, until lost in the ordinary slope of the river. The diagram, plate VII., shews the most characteristic surface lines.

Among the tables will be found the progress of the crest of the tide-wave, and velocity of the bore, with the rate of the stream answering to the various ranges of the tide at Sharpness, including times when the river was under the influence of strong freshes. Between Sharpness and Hock Crib the wave passes at an unusually rapid rate. Captain Beechey considers it posssible that the perpendicular surface of the cliff at Hock Crib, and its situation at right angles to the progress of the wave, may occasion a premature high-water at that particular spot. In the following table, therefore, Hock Crib is omitted, and the interval between Sharpness and Newnham is taken.

TABLE OF VELOCITY OF THE TIDAL WAVE AND BORE OF THE SEVERN AT SPRING TIDES.

Between	TIDAL WAVE. Ft. per Min.	BORE. Ft. per Min.	FLOOD STREAM. Ft. per Min.	EBB STREAM Ft. per Min.
Beachley and Sharpness.....	1,600	374		
Sharpness and Newnham ...	1,944	587		
Newnham and Framilode ...	1,900	475		
Framilode & Rosemary Point	992	820	260	194
Rosemary and Stonebench ...	870	526	350	230
Stonebench and Haw Bridge	1,053	138	240	185
Haw Bridge & Hythe Bridge	729	123		
Hythe Bridge & Upton Bridge	1,053	820		

The above velocities are all appertaining to a spring tide of about 27 feet at Sharpness; the velocity at low water summer level was 52 feet per minute at Stonebench. During the highest flood at this place the river ebbed to about 8 feet above summer low water level, with a velocity of 330 feet per minute.

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* This is not unfrequently the case in rivers having many shoals and considerable fall in their bed.

" After passing Framilode, the rate of the tide wave suffers a material diminution between that place and Rosemary Point. The river, after much encumbrance from sand-banks, assumes its average contracted dimensions, from which it afterwards scarcely deviates to any amount. There are besides some very sharp turns in the river at and above Rosemary, all of which assist in retarding the progress of the wave, so that its rate is reduced to about 10 miles an hour, or half the rate at which it travels at Sharpness; and at this reduced rate nearly it continues its progress up the river as far as the observations can be made with accuracy.

" *The Bore*, or the foot of the wave, travels at a very irregular rate; its advance at all times depends upon the magnitude of the tide; but, in addition to the irregularity arising from this cause, its speed is affected by particular winds, by the shallowness of the river, and especially by low, dry sand-banks. The inclination of the surface of the water it has to surmount also appears to produce a sensible effect upon its rate of travelling. Thus, between Beachley and Sharpness, where the ascent of the low-water surface is 1.75 feet per mile, the bore advances at the rate of 870 feet per minute; and between this place and Rosemary Point, where the ascent is 1.12 feet per mile, the rate of the bore is still only 500 feet per minute; but from Rosemary upwards, where the ascent is only 0.12 foot per mile, the rate increases to upwards of 1,300 per minute, and this easy ascent continuing, the wave continues to roll up the river at a speed nearly double that of its original rate. It must, however, be borne in mind that in all that part of the river where the rate is so small, the river is encumbered with sand-banks, which are the causes also of the rapid descent of the river-surface, the space being occupied by numerous small rapids.

" On a comparison of the rates of the tidal wave and the bore, it appears that, in the early stage of the tide, the crest of the tide-wave is rapidly overtaking the bore, and, consequently, momentarily increasing the height of it; and there can be no doubt that this retardation of the foot of the wave, occasioned by friction of shallows and sand-banks, is the primary cause of the bore. Above Rosemary, the bore, unobstructed by sand-banks, rolls on at a rate which more than equals that of the crest of the wave; and the phenomenon is shortly found to diminish, to lose its wave character as it proceeds, and to become scarcely perceptible above the Partings (Gloucester).

" When the reaches of the river are straight, the bore travels evenly up the river; but at the turnings it is thrown off towards the further side, where it rises higher than in the straight reaches; thence it recoils and impinges upon the opposite shore, and so, like a disturbed pendulum, it oscillates from side to side, and only regains its steady course when the reaches lengthen.

" The highest tide of the year rolled up the Severn on the 1st of December. There were about 2 feet of water above the ordinary summer level in the river, and the morning was calm and favourable to the phenomenon. The stream at low water ran down at the rate of 250 feet per minute, until the bore came rolling up the river with a breast from 5 to 6 feet high at the sides, and 3 feet 6 inches in the centre. The wave was glassy smooth, and as it advanced towards a spectator stationed at Stonebench, a singular effect was produced by the distorted surface of the wave reflecting the rising sun, and brilliantly illuminating the stems and branches of the wood skirting the river as the bore passed along; an effect which greatly enhanced the interest of the phenomenon. The stream turned at the instant after the bore passed, and ran at the

rate of 3,800 feet per minute, which was about half the average rate of the bore, which varied from 12 to 7 miles per hour."

In the table the effect of the fresh, or a certain depth of water in the river, upon the advance of the bore, is remarkable. At dry periods the great obstruction to the progress of the bore lies between Sharpness and Bullo Pill; and, at such times, the many dry sand-banks prevent the bore attaining a rate greater than about 4 miles an hour, as shewn in the table; but when the river is under the influence of freshes, and the water is raised so as to cover some of the banks, it appears to roll on at a rate of 10 miles an hour in opposition to the stream, which about Hock Crib is then running down at the rate of upwards of 4 miles an hour.

The state of the surface fall of the river Severn in flood, which we have tabulated in conjunction with the sectional area, &c., in the sequel, will be found of great value, being a rare example.

The following is a statement of the discharge of this river in the flood of December 4th, 1849, and its relation to the drainage area on that day.

By Captain Beechey's Admiralty survey it appeared that on this day the Severn rose 4.60 at Newnham, and 7.32 feet at Diglis; the particulars of this flood, compared with summer low water, are given in the pages devoted to the "Tides of the Severn." The discharge of the flood below Gloucester was at the rate of 751,245 cubic feet per minute, or 193.12 feet per minute per square mile, being nearly $\frac{1}{8}$ of an inch run off the surface in 24 hours from the drainage area of 3,890 square miles. The summer run of this river, from Captain Beechey's observations, is about 33,111 cubic feet per minute, or 8.49 cubic feet per minute per square mile; this appears to us a low estimate for such mountainous and westerly sources. Plate VII. gives the form of spring tide of this river, with its summer low water and flood surface. The creation of the bore is shewn very distinctly; the same development may be seen in the river Seine, plate XII.

Captain Beechey remarked that the Severn is a river requiring a peculiar treatment, in order to secure its navigable advantages. During summer, the stream possesses but little scouring power; whilst, during rainy periods, freshes rush down the channel with great impetuosity. There is also at springs a very strong upward flow of tide, which frequently tends to take a different course from the downward stream.

When the reaches are straight, both streams pursue the same channel, and for the most part maintain a sufficient depth of water, but at the turnings of the river the streams no longer operate together: the torrent cannot be constrained by the natural bank to flow in the ordinary channel, but forces itself upon the opposite side of the river, which it wears away, leaving a shelf only about low water level. This is the general character of the river at all the turnings.

The continued effect of these torrents has been from an early period to encourage the tortuous form of the river by scouring away the off bank wherever the yielding nature of the soil permitted, until its progress has been arrested by rocky cliffs, or hard stony ground, as above mentioned; hence we see at almost all the sharp turnings of the river, cliffs and hard beds bounding the off side of the bend, with flat ledges projecting from their base. The tortuous form of the river is objectionable from the tendency which the rapid stream, either of downward floods or of the upward flow of spring tide, has to throw up shoals in the eddies of the points wherever the turnings are sharp; and thus we find in the Severn that the silt and debris brought down by the freshes is deposited under these points; the space there at such times being in the eddy, the summer channel is occupied, and in some places for a long period the navigation

of the river is obstructed. It is clear, therefore, that among the various methods which might be suggested for the improvement of the river, a natural one seems to be, that of confining the summer and winter streams to the same channel.

The unequal scour of the streams is particularly remarkable below Hock Crib, where it is the cause of the continual variation of the Nouze and Frampton channels.

The Admiralty survey was especially useful, owing to the borings which were made for the purpose of ascertaining the nature of the bed and subjacent strata of the shoals of the Severn; some of the cross sections are given in plate VII. with these borings.

Sand, the universal component of estuary beds, prevails in the Severn; but the subjacent rocks are generally nearer the surface than usual. They are of the carboniferous series, and the small depth of sand appears to indicate a comparatively recent period for the geological formation of the estuary. The general rapid elevation of the Severn bed (compared with what usually prevails at the mouths of rivers where tide and land-waters meet) on leaving deep water above Beachley, is decidedly shewn by the sections and borings, to be due to geological elevation of the carboniferous rocks, not to fluviatile action; in this respect the evidence is decisive. It is highly probable that the estuary is comparatively recent, taking a cosmological point of view.

THE RIVER AVON.—Plate VIII.

This is a tidal creek of the Severn, with comparatively a small amount of drainage area to affect its tides. Plate VIII. gives a map of the river between the Severn at Portishead and Bristol, with a section exhibiting spring and neap tides. In the following table will be found the heights of these tides for small intervals of time, as taken simultaneously at the mouth and at Bristol. The rapid rise of the bed of this creek appears to obliterate the further rise of the tidal wave; but the velocity of transmission of the wave is very great, as the two places, although 7½ miles apart, have practically the same maximum rise, within 15 minutes; the simultaneous rise of the wave surface is 1 inch per mile *upwards* from the mouth. See report by T. Page, Esq., C.E., from which these data are derived.

The formation of the river Avon is decidedly due to geological causes; the valley is, in fact, a chasm formed by dislocations of the carboniferous rocks of West Somersetshire.

TIDES OF THE SEVERN.

TABLE SHEWING THE HEIGHTS OF HIGH AND LOW WATER.

At Springs and Neaps, and the times of Flood and High Water at the principal points between Portishead and Diglis Lock, (just below Worcester) from Capt. Beechey's survey, 1849.

Note.—The zero of the Tidal Heights is that called the Ordnance Datum or half-tide level at Liverpool, being 4.75 feet above the Old Dock Cill.

Stations.	Distance apart.	Spring Tide. Aug. 20, 1849.			Neap Tide. Aug. 13, 1849.			Time of Flood after making at Beachley Pier.		Time of H. W. after making at Beachley Pier.	
		H.W.	L.W.	Range	H.W.	L.W.	Range	Aug. 20th.	Aug. 13th.	Aug. 20th	Aug. 13th.
	Feet.	Ft. In.	Ft. In.	Ft. In.	Ft. In	Ft. In.	Ft. In.	H. M.	H. M.	H. M.	H. M.
Portishead....											
Beachley	58,000	23 6	19 1	4 2 7	..	..	..				
Sharpness	60,950	25 6	2 0	27 6	16 10	2 6	19 4	2 48	2 36	0 39	0 42
Hock Crib....	39,829	25 11	6 9	19 2	16 10	5 6	11 4	3 54	4 42	0 42	1 08
Newnham	19,552	25 9	9 11	15 10	17 5	8 10	8 7	4 29	5 28	1 10	1 34
Framilode	24,800	26 9	16 1	10 8	17 7	15 1	2 6	4 46	6 38	1 23	2 03
Rosemary	21,000	26 11	17 6	9 5	17 7	16 8	0 11	5 32	7 20	1 36	2 44
Stonebench ..	23,650	25 7	18 2	7 5	..	..	..	6 00	..	2 8	..
Gloucester....	18,940	24 4	18 9	5 7	18 4	17 11	0 5	6 14	..	2 22	..
Haw Bridge ..	40,000	23 1	19 10	3 3	no	tide	felt	7 01	..	3 16	..
Mythe Bridge.	27,800	23 1	21 3	1 10	..	..	..	..	..	3 58	..
Upton Bridge .	29,770	23 5	22 1	1 4	..	..	..	8 12	..	4 16	..
Pixham	34,060	24 5	24 2	0 3	..	..	..	..	..	..	..
Diglis.....	16,780	25 7	25 7	..	25 3	..	..	..	....	..	..

TABLE OF AVERAGE RATE OF THE CREST Of the Tidal Wave and of the Bore,

From Beachley to Upton Bridge, where the latter phenomenon ceases.

SPRING TIDES.	Rate of Crest of Tidal Wave.	Rate of the Bore.
Between	Feet ℘ Min.	Feet ℘ Min.
Beachley and Sharpness	1,599	328
Sharpness and Newnham	1,944	511
Newnham and Framilode	1,900	713
Framilode and Rosemary	996	460
Rosemary and Stonebench	872	1,206
Stonebench and Haw Bridge	1,057	1,075
Haw Bridge and Mythe Bridge	728	713
Mythe Bridge and Upton Bridge	1,058	

TIDES OF THE SEVERN.

TABLE OF FALL AND SECTIONAL AREA OF SUMMER LOW WATER,

Between Portishead and Diglis, from Captain Beechey's Admiralty Survey.

Note.—The datum of the heights given is the Ordnance mean half-tide at Liverpool.

STATIONS.	Distances Apart.	Mean Fall of River Bed per Mile.	Summer Low Water. 4" on Sharpness Gauge, or 7'.9" on Diglis Lock Gauge.				
			Height on Gauge.	Fall per Mile.	Area.	Greatest Width.	Depth.
	Feet.	Feet.	Feet.	Feet.	Sq. Ft.	Feet.	Feet.
Portishead .....(below datum)	..	..	20.31	..	..	..	..
Beachley ..... „	58,000	..	18.90	.013	50,000	3370	46. 0
Inward Point .. „	16,750	1.86	17.55	.425	6,840	2730	5.25
Lidney ..... „	36,500	1.98	3.87	1.98	1,230	670	3. 0
Sharpness ..... „	7,700	1.64	2.79	.74	4,176	1370	11.25
Newnham .....(above datum)	59,381	.80	8.86	1.03	1,900	400	10. 16
Framilode	24,800	.85	15.00	1.31	3,600	450	11.00
Stonebench	44,650	0.36	16.92	.227	632	217	5.50
Glo'ster (say Lower Parting) ..	18,940	..	17.15	.064	783	122	9.00
Haw Bridge.....	40,000	.528	18.81	.219	784	170	6.00
Mythe Bridge	27,800	.265	20.16	.256	570	160	5.75
Upton Bridge	29,770	.301	21.23	.189	..	..	..
Pixham	34,060	.209	23.44	.342	805	125	7.50
Diglis.....	16,780	.392	24.84	.445	255	100	5.00

THE RIVER SEVERN IN FLOOD.

TABLE of the Rate of Fall as indicated by the Gauges

With the Sectional Areas and Fall per Mile in a High Flood, as observed December 4th, 1849.

Note.—These observations were taken at or before low water, when uninfluenced by the Tide.

STATIONS.	Various Freshes.			FLOOD December 4th, 1849.				
	Hght. on Gauge	Hght. on Gauge	Hght. on Gauge	Hght. on Gauge	Fall per Mile.	Area.	Greatest Wdth.	Depth
	Feet.	Feet.	Feet.	Feet.	Feet.	Sq. Ft.	Feet.	Feet.
Portishead	Freshes	not	felt	here	..	..	..	..
Beachley	..	..	..	..	..	..	..	..
Inward Point	..	..	..	..	..	..	..	..
Lidney	..	..	..	..	..	..	..	..
Sharpness..... (below datum)	2.08	2.42	2.58	1.00	..	7,596	2,400	13. 0
Newnham.... (above datum	..	..	..	13.46	1.28	4,522	730	14.75
Framilode.....	15.92	16.66	16.33	19.16	1.21	5,467	500	15.33
Stonebench	17.75	19.25	19.08	25.00	.69	2,582	275	13.25
Glo'ster (say Lower Parting) ..	19.00	20.84	21.16	29.08	1.135	2,328	170	19.50
Haw Bridge	20.75	23.16	23.75	32.84	.496	4,284	320	20.00
Mythe Bridge	22.33	24.92	25.75	35.23	.47	3,945	250	20.50
Upton Bridge	23.58	26.25	27.75	..	.23	..	..	..
Pixham	26.00	28.66	30.50	38.00		3,025	175	22.50
Diglis.....	27.42	30.08	32.16	40.16	.68	2,248	167	20.50

TIDES OF THE SEVERN.

TABLE OF VELOCITIES OF THE TIDAL WAVE AND BORE,

Between Sharpness and Upton, at different ranges of tide, from Captain Beechey's Admiralty Survey of the River, in the summer of 1849.

Names of Stations.	Distances apart.	Range at Sharpness.	Interval of Passage of		Rate per Minute.		
			Wave	Bore.	Wave.	Bore.	Flood Stream
Between	Feet.	Feet.	Min.	Min.	Feet.	Feet.	Feet.
Sharpness and Hock Crib	39, 100	18	23	134	1, 700	292	..
" "	"	20	14½	165	2, 696	237	..
" "	"	21	10	88	3, 910	444	..
" "	"	27	6	66	6, 517	592	389.9
Hock Crib and Newnham.....	19, 550	18	36	44	543	444	..
" "	"	20	29	43	674	455	..
" "	"	21	37	43	528	455	..
" "	"	27	24	41	815	477	..
Sharpness and Newnham	59, 381	27	30	..	1, 979	..	..
Newnham and Framilode.....	24, 800	20	27	62	918	400	..
" "	"	21	15	51	1, 654	486	..
" "	"	27	13	30	1, 907	827	217
Framilode and Rosemary.....	21, 000	21	32	54	656	389	..
" "	"	27	21	40	1, 000	525	435
Rosemary and Stonebench	23, 650	21	..	29	..	816	..
" "	"	27	27	17	876	1, 373	538
Stonebench and Haw Bridge ...	58, 940	21	69	59	854	999	405
Stonebench and Gloucester	"	27	13	17	..	..	405
Haw Bridge and Mythe Bridge	27, 800	27	38	..	732	..	..
Mythe Bridge and Upton.....	29, 770	27	28	..	1, 063	..	..
Haw Bridge and Upton.....	57, 570	27	..	70	..	822	..

Rate of Flood Stream, Dec. 1st, 1849,

Being Spring Tides, was about 400 feet per minute, near Stonebench, as taken by a Float drifting, but properly watched.

Sectional Area then about 2,150 square feet.

Rate of Ebb Stream, Dec. 11th, 1849,

Being Average Tides, was about 275 feet per minute, near Stonebench, as taken by a Float drifting, but properly watched.

Sectional Area then about 1,700 square feet.

TIDES OF THE AVON.

TABLE SHEWING RISE AND FALL OF A SPRING AND NEAP TIDE

At Cumberland Basin, Bristol, and at Avon Mouth.

The distance apart is seven miles; sectional area of River at Rownham Ferry when High Water ordinary Spring Tides 6,848 square feet, same at 5 miles 550 yards below 16,400 square feet.

Datum, Zero of Cumberland Basin Gauge.

SPRING TIDE, March 9th, 1860.						NEAP TIDE, March 16th, 1860.					
Time.	Cumberland Basin.	Avon Mouth.	Time.	Cumberland Basin.	Avon Mouth.	Time.	Cumberland Basin.	Avon Mouth.	Time.	Cumberland Basin.	Avon Mouth.
h. m.	ft. in.	ft. in.	h. m.	ft. in.	ft. in.	h. m.	ft. in.	ft. in.	h. m.	ft. in.	ft. in.
3.45 a.m	3. 2	-13. 8	10. 15 a.m.	23. 0	21. 7	7.30 p.m.	2. 0	-1. 0	2. 0 a.m	14. 10	14. 8
4. 0 ,,	3. 2	-10. 6	10.30 ,,	21. 8	19. 1	7.45 ,,	2. 1	-0. 10	2.15 ,,	14. 11	14.10
4.15 ,,	3. 3	-9. 1	10.45 ,,	18. 6	16. 10	8. 0 ,,	2. 2	0. 5	2.30 ,,	15. 0	14. 9
4.30 ,,	3. 2	-6. 9	10. 0 ,,	16. 4	14. 5	8.15 ,,	2. 6	0. 0	2.45 ,,	15. 0	14. 8
4.45 ,,	3. 1	-4. 7	10.15 ,,	14. 4	12. 6	8.30 ,,	2. 11	0. 7	3. 0 ,,	14. 11	14. 5
5. 0 ,,	3. 1	-2. 7	10.30 ,,	12. 5	10. 7	8.45 ,,	3. 0	1. 4	3.15 ,,	14. 6	14. 0
5.15 ,,	3. 0	1. 3	10.45 ,,	10. 8	8. 9	9. 0 ,,	3. 0	2. 1	3.30 ,,	14. 0	13. 6
5.30 ,,	3. 0	4. 0	Noon	9. 2	7. 0	9.15 ,,	3. 1	2.10	3.45 ,,	13. 2	12.10
5.45 ,,	2. 11	7. 1	12.15 p.m.	7. 11	5. 3	9.30 ,,	3. 9	3. 7	4. 0 ,,	12. 5	12. 2
6. 0 ,,	6. 5	10. 5	12.30 ,,	6. 7	3. 6	9.45 ,,	4. 1	4. 3	4.15 ,,	11. 8	11. 4
6.15 ,,	10. 8	13. 7	12.45 ,,	5. 5	1. 9	10. 0 ,,	4.10	5. 0	4.30 ,,	10. 11	10. 5
6.30 ,,	15. 3	17. 1	1. 0 ,,	4. 7	0. 0	10.15 ,,	5. 8	5. 9	4.45 ,,	10. 0	9. 6
6.45 ,,	19. 0	20. 2	1.15 ,,	3.10	-1. 9	10.30 ,,	6. 5	6. 7	5. 0 ,,	9. 1	8. 7
7. 0 ,,	21. 10	22. 10	1.30 ,,	3. 4	-3. 4	10.45 ,,	7. 2	7. 4	5.15 ,,	8. 2	7. 7
7.15 ,,	24. 7	25. 6	1.45 ,,	3. 0	-4. 10	11. 0 ,,	8. 1	8. 2	5.30 ,,	7. 0	6. 8
7.30 ,,	27. 5	27. 9	2. 0 ,,	2. 11	-6. 3	11.15 ,,	8. 11	8. 11	5.45 ,,	6. 1	5. 9
7.45 ,,	30. 0	29. 7	2.15 ,,	2. 9	-7. 5	11.30 ,,	10. 0	9. 8	6. 0 ,,	5. 3	4.10
8. 0 ,,	31. 8	31. 0	2.30 ,,	2. 8	-8. 7	11.45 ,,	10. 9	10. 5	6.15 ,,	4. 8	4. 0
8.15 ,,	32. 7	32. 1	2.45 ,,	2. 7	-9. 7	M. Night.	11. 2	11. 1	6.30 ,,	3.11	3. 3
8.30 ,,	33. 2	32. 6	3. 0 ,,	2. 7	-10. 6	12.15 a.m.	11. 7	11. 9	6.45 ,,	3. 4	2. 6
8.45 ,,	33. 2	32. 4	3.15 ,,	2. 7	-11. 5	12.30 ,,	12. 1	12. 4	7. 0 ,,	2. 11	1.10
9. 0 ,,	33. 2	31. 9	3.30 ,,	2. 8	-12. 2	12.45 ,,	12. 8	12. 11	7.15 ,,	3. 3	1. 4
9.15 ,,	31. 11	30. 4	3.45 ,,	2. 9	-12. 9	1. 0 ,,	13. 6	13. 5	7.30 ,,	3. 6	0.10
9.30 ,,	29. 11	28. 4	4. 0 ,,	2. 9	-13. 3	1.15 ,,	14. 2	13.10	7.45 ,,	3. 5	0. 6
9.45 ,,	27. 6	26. 7	4.15 ,,	2. 9	-13. 7	1.30 ,,	14. 6	14. 2	8. 0 ,,	3. 1	0. 3
10. 0 ,,	24. 11	24. 0	4.30 ,,	2. 11	-11. 8	1.45 ,,	14. 9	14. 6	8.15 ,,	2.10	-0. 9

LEVELS OF SURFACE OF WATER

Taken simultaneously at dead low water, at various Stations between Netham Dam, and the mouth of River.

Datum, Zero of Cumberland Basin Gauge.

At 9 a.m., after a **NEAP TIDE**, rising 17 feet 7 inches on 17th March, 1860.				At 2.30 p.m., after a **SPRING TIDE**, rising 29 feet 9 inches, on March 23rd, 1860.			
Distance from Rownham.		Height.	Surface Slope.	Height.	Approximate surface velocity in mid stream at time of observation.	Surface Slope.	Lowest level to which water sank after observations were taken.
Miles.	Yards.	Feet.	1 in	Feet.	Ft. per sec.	1 in	Feet.
3	1320	17.89	.....	17.17	2.92	.....	.....
3	,,	17.00	4444	16.35	2.99	4829	16.33
2	440	15.80	3300	15.49	2.80	4604	.....
2	,,	15.16	2062.5	14.62	4.01	1517.2	14.62
1	,,	9.54	939.5	9.56	3.48	1043.4	9.04
Rownham		2.92	797.6	3.58	.....	822.9	2.42
0	1675	-0.06	1686.3	0.55	3.66	1658.4	-0.90
2	,,	-1.15	5078	-2.44	2.61	1851.2	-3.59
3	,,	-1.27	.....	-3.89	4.37	3641.3	-5.06
4	,,	-1.40	.....	-5.15	2.55	4190.5	-5.97
5	600	-1.56	.....	-7.47	2.97	2974.1	-8.13
6	1440	-1.75	.....	-9.11	.....	4865.8	-9.36

THE RIVER SEINE ESTUARY.—Plate XII.

The Seine affords a remarkable example of the effect of sand-banks and other obstructions at the embouchure of a river upon the propagation of the tidal wave. In consequence of these obstructions, the foot of the wave assumes, at spring tides, the form of a "Bore," frequently of great height; this and the accompanying phenomena are in many respects similar to those in the Severn, and tend strongly to confirm the remarks made upon that river. We have therefore extracted the various facts given in a valuable memoir on the subject, by Partiot, Engineer of the "*Ponts et Chaussées*," see Vol. 1, 1861.

Plate XII., which is compiled from the same source, shews the form assumed by the wave surface, in its passage up the river.

The Seine empties itself into the sea at Hâvre, where the tidal range is at springs, 22 feet, and at neaps, 18 feet. Its general direction from Hâvre to Tancarville and Quillebeuf is nearly due east, after which it gradually tends to about S.E., in which direction it continues until it reaches Paris. Throughout its whole length the course is extremely tortuous, in many instances the bends forming more than half a circle. At Quillebeuf, what may strictly be called the Estuary commences; the channel (which higher up is of comparatively small width), suddenly expands, and gradually increases in width, to the parallel of Honfleur, immediately above which it attains to its maximum of 3,700 feet. At Honfleur the width contracts to 2,300 feet on a line joining it and the opposite "Point du Hode" on the northern shore; from this line the estuary again widens out until it attains a width of 3,000 feet on a line joining Hâvre and the opposite Point of Villerville, which may be considered as the limit of the estuary From La Mailleraye to Tancarville the river is embanked continuously on the northern shore, and on the southern, to a sufficient extent to render the channel uniform, as far as a point midway between Quillebeuf and the latter point. The general fall of the river bed, as indicated by the low water surface shewn on the section, varies from .01 to .13 feet per mile above Quillebeuf, whilst from this point to the sea the fall is very much greater, varying from .33 to .83 feet per mile, and the whole estuary is choked with sand-banks. The channel winds amongst these banks, and bifurcates a little above the Point du Hode; one of the channels keeping along the north shore and passing by Hâvre, the other keeping to the south by Honfleur.

Between the years 1855 and 1860, several observations were made and experiments tried to determine the rate at which the foot of the wave travelled; the velocity of the bore, the velocity of the streams of both flood and ebb, and other circumstances bearing upon the subject. The observations from which the tables and plate are compiled were taken every ¼ hour on the 18th August, 1856, two days after full moon. The wind was from the N.N.E., and the water at Mantes (above the influence of the tide) stood 6 inches higher than the ordinary summer level. The watches of the observers were carefully set to Paris time at the nearest stations of the Paris and Hâvre Railway.

The table of the Seine, in the sequel, gives the simultaneous observed heights of the tide extending for 100 miles from the mouth of the river; the velocities of the head and foot of the tidal wave (but not of the bore itself), are given in a second table computed therefrom. From this table it will be seen that between Hâvre and Tancarville, where the bed of the river rises rapidly and is much encumbered by sand-banks, as before stated, the velocity of the foot of the wave was only 557 feet per minute, or nearly 6½ miles per hour; whilst from Tancarville upwards, where the channel is more regular, the mean velocity

was 1,274 feet per minute, or 14½ miles per hour. The velocity of the flood stream at Villequier, 332 feet per minute, immediately after the passage of the wave; and half-an-hour later it attained its maximum of 362 feet per minute. The *ebb* stream did not commence to run downwards until the tide had fallen 3.2 feet after high water. The remarkable parallel between these facts and those observed by Captain Beechey on the Severn, which will be seen on reference to the tables of that river, give additional weight to his observations on the origin of the bore, in which both rivers are similar.

Critical examination of the tidal waves and streams in plates I. to IV.B will throw much light on the manner in which these estuaries of tidal wave-producing character are affected by the generating tides whence they spring. The estuaries of the Seine, Lynn, St. Malo, and Severn have all a family likeness, the ebb and flow at the mouth being such as to produce a duplicate effect.

AS TO THE BORE OF THE SEINE.

On the 6th May, 1856, the second day after new moon, the following observations were made at St. Jacques, between Le Hode and Tancarville, at which point the bore attains its greatest development. The depth of water in the channel below Le Hode was only 14 inches. At 8.20 the ebb stream was still running down; the bore could then be distinguished forming itself in the whole of the southern part of the bay. The tidal wave arrived first from the south, the sand-banks on that side of the bay being less elevated than on the north; after having covered a portion of these banks, it then began to come in from the north. It arrived at St. Jacques at 8h. 29m. For ten minutes previous to this the water level had not varied sensibly, the stream had continued to run downwards, and no indication of any kind had preceded the wave itself. The height of the first wave forming the bore, measured on a fixed tide gauge, was 7.15 feet; it was followed by five or six secondary waves, having intervals between their crests of from 5 to 7 feet. After their passage, the surface became tolerably calm, and at 8h. 31m. 15sec., or 2m. 15sec., after the arrival of the bore, it stood at 5.5 feet above low water. At about 8h. 40m. the northern bore arrived, causing an elevation of about 16 inches.

On the 7th March, 1860, during a flood, when the water stood 14.9 feet above summer level at Mantes, the bore attained a height of 3.6 feet at Tancarville, where it arrived at 9h. 5m.

Above Tancarville and Quillebeuf the bore is again developed, wherever the channel becomes shallow, disappearing where it is deep.

At Vieux Port, on the 5th May, 1856, the day after new moon, the tide fell continuously up to nine o'clock. It then rose 3 inches in 4m. 40sec., the stream still running down; at this moment the Bore arrived, producing a sudden rise of 5.45 feet in the water surface. About 6 minutes afterwards there was a sudden drop of 16 inches, after which the water again began to rise regularly, and attained the level which it had at first suddenly acquired in 12m. 30sec., after the arrival of the bore. By means of observations at a point 5,020 feet higher up the river, the velocity of the bore was found to be 1,055 feet per minute.

The bore sometimes attains the height of nearly 10 feet below Tancarville, and in a great portion of the length between Quillebeuf and Duclair. In this part experiments were made with three floats, viz., one

swimming on the surface and two others loaded so as to swim at 3.3 feet and 8.2 feet below the surface respectively. The depth of the channel was from 16 to 20 feet. The experiments were made on the 25th September, full moon, and three following days. The following are the results:—

Date.	Wave arrived in Mid Channel at	Floats started at	Distance passed over.	Time occupied, and Velocities of Floats.						Height of River at Mantes.
				1st.		2nd.		3rd.		
				Time.	Vel.	Time.	Vel.	Time.	Vel.	
1855.	H. M.	H. M.	Feet.	Secs.	Ft. per Min.	Secs.	Ft. per Min.	Secs.	Ft. per Min.	Feet.
25 Sep.	7 14	7 36	1640	362	272	360	275	365	270	0. 59
,, ,,	7 14	8 17	3280	365	540	363	542	360	550	,, ,,
26 ,,	8 10	9 2	3280	364	541	362	544	360	550	0. 39
27 ,,	8 39	9 46	3280	304	647	302	651	300	656	0. 43
28 ,,	9 0	9 35	1640	300	328	300	328	300	328	0. 46
,, ,,	9 18	10 18	3280	365	540	363	542	360	550	,, ,,

The velocity, a little after the arrival of the wave, was less than that about an hour later, which, however, did not exceed 655 feet per minute. The velocity of the Bore was always, even under the most favourable circumstances, much less than that at which the wave was propagated. This latter being on the average 1,067 feet per minute, the day after new moon. Finally, it will be observed that the lowest float had in nearly every instance greater velocity than the other two, which would appear to prove that the current was greater at mid depth than at the surface.

On the 27th August, 1855 (full moon), a surface float was placed between La Mailleraye and Caudebec at 8.57 a.m. This float moved downwards over a space of 1,970 feet, at the rate of 197 feet per minute, the velocity then lessened, and the float passed over a space of 2,790 feet, at the rate of 121 feet per minute; after that the velocity was reduced to 116 feet per minute. At 9.26 the float encountered the tidal wave, and became motionless for 40 seconds, after which it recommenced to travel downwards, slowly traversing a space of 49 feet in 2m. 35sec. It then commenced to travel upwards, moving at first only 7½ inches in 8m. 50sec., then 2.5 feet in 18m. 25sec., and finally it arrived at its point of departure at 10h. 7m. 15sec., travelling at the rate of 183 feet per minute.

On the 13th and the 25th September, 1855, experiments were tried with floats at Caudebec. On the 13th, two floats were used, viz.;—one at the surface, and one 10.8 feet below, and on the 25th three were used, viz.:—at the surface, at 5 feet below, and at or near the bottom. In both experiments the lower floats began to ascend the river on meeting the tidal wave, some seconds before those on the surface. On the 25th, the difference was as much as 2m. 15sec.

These facts tend to shew that in the middle of the Seine, where the bore assumes the form of an undulation, the ascending current is not produced immediately after the passage of the wave, that it is propagated *from the banks towards the centre*, and that it commences at the *bottom of the river sooner than at the surface.*

TIDES OF THE SEINE.

TABLE OF THE RISE AND FALL OF A SPRING TIDE,

At various points, taken simultaneously from the mouth of the river to the end of the tidal range at the Pont de l'Arche, extracted from a Paper by Mons. Partiot, Ingenieur, in the "Annales des Ponts et Chaussées," 1861.

Zero is level with the Cill of the Sluice of Vauban's Canal at Le Hâvre. Sectional area of river at Vieux Port, between Quillebeuf and Villequier, at Low Water 12,514 square feet, and at High Water 24,100 square feet.

SPRING TIDE, August 18th, 1856, two days after Full Moon.

Time.	Le Hâvre	Tancarville.	Quillebeuf.	Villequier.	La Mailleraye.	Duclair.	Rouen.	Elbeuf.	Pont de l'Arche.
H. M.	Ft. Dec	Ft. Dec	Ft. Dec	Ft. Dec	Ft. Dec	Ft. Dec	Ft. Dec	Ft. Dec	Ft. Dec
6 30 a.m.	−2.5LW	9.6	12.3	14.3	15.4	16.8	19.0	19.7	20.9
7 0 ,,	−0.8	9.5	12.2	14.2	15.3	16.6	18.5	19.3	20.8
7 30 ,,	2.0	9.4	12.1	14.2	15.3	16.3	18.2	19.1	20.6
8 0 ,,	5.9	9.3	12.0	14.1	15.0	16.1	18.0	18.9	20.5
8 30 ,,	11.4	9.3	12.0	13.8	14.9	15.9	17.6	18.7	20.4
9 0 ,,	16.2	9.2	11.9	13.8	14.8	15.6	17.3	18.5	20 2
9 15 ,,	17.7	9.1LW	11.8	13.6	14.7	15.5	17.2	18.4	20.2
9 30 ,,	19.0	14.0	11.8	13.6	14.6	15.4	17.1	18.1	20.2
9 45 ,,	20.0	15.2	11.7LW	13.6	14.4	15.4	16.9	18.0	20.1
10 0 ,,	20.7	18.2	14.6	13.5	14.4	15.2	16.8	17.8	20.0
10 15 ,,	21.2	20.3	18.0	13.5	14.3	15.0	16.7	17.7	20.0
10 30 ,,	21.5HW	21.7	19.5	13.4LW	14.2	14.9	16.6	17.5	19.9
10 45 ,,	21.6	22.5	20.4	17.0	14.1	14.8	16.5	17.5	19.9
11 0 ,,	21.5	23.0	21.1	18.5	14.0LW	14.7	16.4	17.4	19.9
11 15 ,,	21.6	23.1HW	21.5	19.5	14.0	14.6	16.3	17.2	19.8
11 30 ,,	21.6	22.7	21.7HW	19.9	18.0	14.5	16.2	17.1	19.7
11 45 ,,	21.7	22.2	21.5	20.4	19.5	14.4LW	16.1	17.1	19.7
12 0 ,,	21.4	21.6	21.2	20.8	20.2	14.4	15.9	17.0	19.6
12 15 p.m.	21.2	21.1	20.8	21.1HW	20.5	18.2	15.8	16.9	19.6
12 30 ,,	20.8	20.5	20.4	21.1	20.6HW	18.5	15.8	16.8	19.6
12 45 ,,	20.4	20.1	20.3	20.8	20.4	18.8	15.7	16.8	19.6
1 0 ,,	20.0	19.9	20.0	20.7	20.2	18.9	15.6	16.7	19.6
1 15 ,,	19.2	19.6	19.8	20.2	20.0	19.1	15.5LW	16.6	19.5
1 30 ,,	18.4	19.4	19.6	19.8	19.6	19.3HW	17.4	16.5	19.5
2 0 ,,	16.0	18.9	19.1	19.1	19.1	19.2	18.1	16.4	19.5
2 30 ,,	13.1	17.6	18.6	18.6	18.7	19.0	19.0	16.3LW	19.4
2 45 ,,	11.4	16.9	17.6	18.4	18.6	18.9	19.3	17.0	19.3
3 0 ,,	9.3	16.1	17.0	18.2	18.4	18.8	19.7	17.8	19.2LW
3 30 ,,	6.5	14.2	16.0	17.5	18.0	18.7	19.9	18.7	19.5
4 0 ,,	4.2	12.7	14.7	16.6	17.3	18.6	20.1HW	19.3	19.8
4 30 ,,	2.3	11.8	14.0	16.0	16.7	18.2	20.1	19.7	20.3
5 15 ,,	0.4	10.5	13.2	15.0	16.0	17.4	20.1	20.0HW	20.8
5 45 ,,	−0.8	10.2	12.7	14.7	15.8	17.2	19.8	19.9	20.9HW

VELOCITIES OF THE FOOT AND HEAD OF TIDAL WAVE.

Names of Stations.	Distances apart.	Tidal Range.	Interval of Passage of Foot of Wave.	Interval of Passage of Head of Wave.	Rate per Minute. Foot.	Rate per Minute. Head.
Between	feet.	feet.	Mins.	Mins.	feet.	feet.
Hâvre and Le Hode	65,618	24.0	165	45	557	2,041
Le Hode and Tancarville	26,247	17.4				
Tancarville and Quillebeuf	37,730	14.1	30	15	1,258	2,516
Quillebeuf and Villequier	61,517	9.6	45	45	1,367	1,367
Villequier and La Mailleraye	33,794	7.8	45	15	751	2,253
La Mailleraye and Duclair	82,678	6.6	45	60	1,837	1,378
Duclair and La Bouille	61,353	5.0	30	105	2,045	584
La Bouille and Rouen	59,384	4.6	45	45	1,320	1,320
Rouen and Elbeuf	77,100	5.4	75	75	1,028	1,028
Elbeuf and Pont de l'Arche	38,714	3.7	30	30	1,290	1,290
Hâvre and Pont de l'Arche	544,135	1.7	510	435	1.067	1.251

THE GIRONDE ESTUARY.—Plate XII.

The section of the Gironde Estuary of the Garonne is reduced from one annexed to M. Partiot's memoir. The surface slopes are shewn at the commencement of the bore, with those at high and low water; the form of wave is analogous to that of the Seine; but the character is not so violent as in the Severn or Seine, and the cause is shewn in the absence of sand banks with rapid fall at the opening out of the estuary; the low-water line is very different from that of the other rivers. Sufficient detailed information is not given, to allow of the compilation of a table of heights and velocities.

THE TIDES OF THE HOOGLY.—Plate XVI.

This river has great peculiarities; like its parent the Ganges, it is full of shifting sands. Its bore is not unlike that of the Severn, but in rise of tide is far inferior, being more like the Seine in that respect. The Baghirutte and Jellingee branch out of the Ganges, at a very considerable distance apart, but join about 60 miles above Calcutta and form the deltaic branch of the Ganges, which becomes the Hoogly where the tides flow. In the dry season of the year, between November and March, these rivers carry very little water, so that the Hoogly tides are then certainly not affected by the volume of fresh water. But when the flood period of the Ganges is at its height, in August and September, it fills the Hoogly and spreads over the adjoining plains; the entire body of the river is raised between 4 and 7 feet at Calcutta, varying with the tides and volume of flood water descending from the inundation.

The first idea of a high spring tide meeting a flooded backwater is that the great upward volume of water dams back and forces into increased height the downward waters; but against this effect we have to place the fact, that the increased height of water affords greater sectional area on the turn of tide, and thus affords higher power of discharge, up to the time of low water; and again, however great the rising tide, it can but receive the downflowing waters into its breast; there is no dynamic force which can throw the waters backwards or higher by reason of the mere fact of the waters being increased in volume. It is from these considerations that it is very much to be doubted whether spring tides are not, *cæteris paribus*, instrumental in effecting the discharge of floods, although they may occasionally assist in raising the top of high water in extreme cases. Increase of sectional area must decidedly reduce the height of tidal wave, *per se*, just as *per contra* shoals are creative of the bore.

It is not easy to predict the exact effect of flood water upon the tidal wave; greater capacity of channel for the passage of the wave must necessarily predicate an earlier establishment and a flatter undulation; or, in other words, greater velocity of wave; and accordingly we find by the following table, that on comparing the low waters of four spring and neap tides in two months of high flood, with the same number of tides in two months of drought, there is 3 ft. 11 ins. elevation by flood at low water springs, and 5 ft. 6 ins. elevation at neaps; but the high waters under the same conditions are raised by floods 6 feet at springs, and 5 ft. 6 ins. at neaps; the increased sectional area, therefore, gives a greater proportional effect to spring tides in clearing off flood water, or, in other words, the river is decidedly not so much gorged by floods during spring tides as during neaps.* The probable cause is that there appears to be a greater swing

* It is quite consistent that springs should rise higher during floods from the better access of the tidal flow from the Bay of Bengal. For similar conditions we may refer to the tide lines of the Severn, plate VII, and remarks on the effect of freshes at page 261.

of tide at low-water springs than at neaps, which therefore assists in delivering the downward stream of waters by the increased rate of fall thereby acquired. By the last table it will be seen that the mean half-spring tide line is elevated by floods 4 feet 11.5 inches, but in neaps it is elevated 5 feet 6 inches. These facts are quite consistent with what we have observed in the case of the very rare floods which can sensibly affect the Thames. We will content ourselves by leaving to the student of these peculiarities the following tables; the subject is one that falls under consideration of the engineer practically, and the case of the Hoogly is an excellent test of the kind of effect produced on tides by alteration of depth and volume.

The table, page 273, contains the heights of one spring and neap tide for each lunation for one year, viz., from the 1st July, 1843, to the 24th of June, 1844. From this table is constructed a diagram (fig. 1), plate XVI., which shews the gradual swelling of the tides during the flood season and the concurrent lines which join the extreme tides of each class.

The remaining tables contain the results of comparisons of the mean of four spring and neap tides in the seasons of flood and drought, with the comparative effect on the various levels of high and low water, of the mean range of tide, and of the mean half-tide level, above referred to.

CONCLUDING REMARKS.

We have now finished our sketch of the different Tidal rivers with the tables in which their various peculiarities are exhibited. The object has been to pourtray the actual condition and effect of tidal phenomena, such as the velocities of the tidal waves, sectional area, width, depth, &c., in each case; so that any one wishing to search for a precedent as it were, to shew what may be expected, under given circumstances, can here find, at all events, an approximation to the investigation. Much more could be done if professional men would find time to follow up the subject, and we have an earnest hope that this will be done. Constant calls from our daily avocations have broken in upon and frequently destroyed the work of long previous consideration, which has had again to be taken up at a great sacrifice of time and labour. In the labour we have, at all events, found that there is a mine of unexplored phenomena open to inquiry; the great aim of our own study has been to trace out the bearings of the laws of gravity, with which the Tables commence, and which determine all hydrodynamic computation, and to shew how they are affected by friction, and other resistances; all are mere modifications of this first cause, and the practical result of their various forms and conditions is what the Engineer requires for a skilful adaptation of his works.

Plates XVII. and XVIII. contain the curve of tides for Spring and Neaps for several places in the English and Irish Channels. They contain the extreme cases of great tidal wave on the Severn, and small wave at Yarmouth; also the tides at Portland and Cardigan, which have a long irregular low water, owing to their embayed position; and Southampton, which has a period of rest at an intermediate period between high and low water. Attention may be drawn also to the tides of the Seine, which has a very unusual period of high water.

The three remaining Tables in this division contain schedules of the size and dimensions of the principal docks in the United Kingdom. Those of the Mersey and Port of London are brought up to the present date (March, 1861), but some of the places at page 276 are only as up to 1853. Very large docks have been since constructed at Hull, Sunderland, the Tyne, Dublin, Cardiff, Swansea, &c. We have not included in the Tables any of the great naval docks, in the dimensions of which such strides have been made.

RIVER HOOGLY, AT CALCUTTA.

TABLE OF SPRING AND NEAP TIDES for the Year 1843-44.

Datum is Zero of Kidderpore Old Dock Tide Gauge; morning tides only are recorded.

DATE. 1843-4.	SPRINGS. H. Water.		L. Water.		Differnce.		DATE. 1843-4.	NEAPS. H. Water.		L. Water		Diffnce.	
	Ft.	Ins.	Ft.	Ins.	Ft.	Ins.		Ft.	Ins.	Ft.	Ins.	Ft.	Ins.
July 1	17	3	5	0	12	3	July 7	14	10	7	0	7	10
13	17	10	5	10	12	0	21	14	7	9	3	5	4
29	20	0	6	8	13	4	August .. 5	16	0	8	6	7	6
August ... 12	20	3	7	10	12	5	20	14	5	9	10	4	7
27	21	0	7	2	13	10	September 4	15	6	9	2	6	4
September 10	19	2	7	2	12	0	18	14	6	9	9	4	9
26	20	3	6	10	13	5	October ... 2	14	0	8	0	6	0
October ... 10	18	8	6	4	12	4	17	14	6	8	5	6	1
24	19	0	6	6	12	6	30	14	10	7	6	7	4
November 8	14	10	5	8	9	2	November 16	12	4	5	4	7	0
23	15	8	3	8	12	0	30	11	3	4	8	6	7
December . 8	13	9	4	5	9	4	December 16	11	2	3	10	7	4
23	14	8	3	8	11	0	31	10	6	4	8	5	10
January ... 7	13	8	3	10	9	10	January... 15	10	1	3	6	6	7
21	13	8	3	0	10	8	30	9	3	4	1	5	2
February . 6	14	2	2	6	11	8	February 13	9	6	3	2	6	4
21	15	1	3	0	12	1	28	9	6	4	6	5	0
March 6	16	5	3	4	13	1	March ... 13	9	11	3	8	6	3
27	15	0	3	3	11	9	29	9	8	4	4	5	4
April 5	17	8	2	4	15	4	April 11	10	0	4	3	5	9
19	16	7	3	8	12	11	27	11	6	5	6	6	0
May 3	17	11	3	7	14	4	May 10	12	2	5	4	6	10
16	16	0	4	7	11	5	25	12	1	5	3	6	10
June..... 2	17	6	3	8	13	10	June 8	12	10	6	0	6	10
17	16	1	5	4	10	9	24	14	0	6	5	7	7
Mean	16	11	4	9	12	2	Mean.....	12	4	6	1	6	3

Table of High Water at Springs and Neaps, in Flood and Dry Seasons.

(From mean of four morning tides in Aug., Sept., Jan. and Feb.)

	Floods.		Dry Season.		Elevation by Floods.		
	Ft.	Ins.	Ft.	Ins.	Ft.	Ins.	
Mean of High Water Springs.....	20	2	14	2	6	0	SHW
,, ,, Neaps	15	1	9	7	5	6	NHW
Difference of High Water at Springs & Neaps.	5	1	4	7	0	6	

Low Water at Springs and Neaps, in Flood and Dry Seasons.

Mean of Low Water, Springs.....	7	0	3	1	3 11	SLW
,, ,, Neaps	9	4	3	10	5 6	NLW
Difference of Low Water at Springs & Neaps	2	4	0	9	1 7	

Mean Rise of Tide and Half-tide.

Mean rise of Spring Tides	13	2	11	1	2	1
,, Neap ,, ...	5	9	5	9	0	0
Difference of Spring and Neap rise	7	5	5	4	2	1
Half-tide line above zero at Springs is	13	7.0	8	7.5	4	11.5
,, ,, Neaps is	12	2.5	6	8.5	5	6.0
Difference of half-tide at Springs and Neaps	1	4.5	1	11.0	0	6.5

Therefore the mean elevation by floods is 5 feet 9 inches; the maximum being at high-water Neaps 5 feet 6 inches, and minimum being at low-water Springs, 3 feet 11 inches.

PORT OF LONDON.

Dimensions and Area of Docks, and Length and Width of Entrance Locks, with Level of Sills below Trinity High Water.

DOCKS.	Area of Water Space.	Depth below T.H.W.	Quay-age.	Length of Lock.	Br'dth. of Lock.	Depth over Sills.
	Acres.	ft. in.	yds.lin.	ft. in.	ft. in.	ft. in.
ST. KATHARINE'S.						
West Dock	4	24.0	570			
East Dock	4¾	24.0	570			
Tidal Basin	1¼	24.0	320	180.0	45.0	28.0
	10					
LONDON.						
Western Dock	20	...	1,700			
Tobacco Dock and Passage	¾	...	300			
Eastern Dock	6¼	...	670			
Hermitage Basin	1	...	250	155.0	40.0	19.9
Wapping Basin	3	...	400	170.0	40.4	23.0
Shadwell Basin ... New Lock	6½	...	660	350.0	60.0	28.0
Shadwell Basin ... Old Lock				180.0	44.6	25.4
	37½					
REGENT'S CANAL.						
Limehouse Basin	8½	20.6	...	134.0	32.0	18.6
WEST INDIA.						
Import Dock	30	...	2,085			
Export Dock	24	...	2,020			
Junction Dock	1½	25.0	245	...	45.0	25.0
South Dock	14	...	1,150	192.0	45.0	23.7
Timber Dock	16	...	..	192.0	45.0	23.2
Limehouse Basin	1	...	235	155.0	36.0	22.0
Blackwall Basin	7	...	600	191.6	45.7	24.2
Railway Dock	6¼	20.0	680	130.0	30.0	
	98¾					
EAST INDIA.						
Import Dock	18	...	1,300			
Export Dock	8	...	810			
Tidal Basin	4¾	23.0	640	215.0	47.8	24.8
	30¾					
VICTORIA.						
Dock	74	24.0	2,360			
Tidal Basin	16	24.0	1,000	326.6	80.0	28.0
	90					
***THAMES GRAVING DOCK.**						
Pontoon Water Space	9	7.0				
Hydraulic Lift	...	...	...	500.0	62.0	18.6
GRAND SURREY.						
Tidal Basin	2¾	27.0	416	250.0	50.0	27.0
Main Dock	13	27.0	1,200	128.0	32.0	19.0
Outer Dock	10¾	19to27	1,667			
Upper Dock	13½	19.0	850			
Timber Pond, No. 1	15½	6.6				
——— No. 2	11¼	9.0				
——— No. 3	15½	7.0				
——— No. 4	18	7.0				
	101					
COMMERCIAL.						
New South Dock	6	27.0	716	220.0	48.0	27.0
Dock No. 1	9¾	18.6	860	209.0	42.6	18.6
Dock No. 2	3¾	18.6	558			
Dock No. 3	10	16.6	870			
Timber Pond No. 1	15	10.0	180			
——— No. 2	18½	10.0	...	320.0	34.0	18.6
——— No. 3	7	10.0				
	70					

NOTE.—The total area of Docks in London given in the above Table amounts to 330 acres; of Timber Ponds 126 acres. In addition to this, upwards of 3 miles of the river are used for unloading and about 4 miles of River frontage between Vauxhall and Blackwall are more or less occupied by wharves and manufactories, which are approached by short entrances from the river. The Regent's Canal Dock, which is the largest single Dock in London, belongs to the Regent's Canal Company, and is used for the trade of that Company. The Hydraulic Lifts of the Victoria Docks are the only public Graving Docks other than those belonging to the Admiralty at Deptford and Woolwich. The power of the Hydraulic Lift is 6,400 tons, length 308 feet, capable of taking vessels 850 feet long. The Pontoons vary in length from 156 feet to 320 feet by 60½ feet in width; the largest will carry a dead load of 3,300 tons, in addition to its own weight.

RIVER MERSEY DOCKS.

TABLE of the Dimensions and Depth over Sills of Docks and Basins, &c.

LIVERPOOL DOCKS.	Width of Entrance.	Sill under Old Dock Datum.	Water Area.	Quay Space.
	ft. in.	ft. in.	acres.	yards
North Carrier's Dock ..	40 0	6 0	2.7	641
South ditto	40 0	6 0	1.9	615
Canada Half-tide Dock..	30 &32	7 9	3.8	468
Canada Dock	50 &80	6 6	17.8	1272
Canada Lock	100 0	7 9	1.7	497
Huskisson Dock.....	80 0	...	14.7	1039
Huskisson Branch Dock	...	...	7.1	910
Huskisson East Lock ..	80 0	6 6	0.9	342
Huskisson West Lock ..	45 0	6 0	0.7	330
Sandon Dock	70 0	6 6	10.0	867
Wellington Hf.-tide.Dock	70 &50	6 9	3.1	400
Wellington Dock	70 0	6 6	7.8	820
Bramley-Moore Dock ..	60 0	6 0	9.6	935
Nelson Dock	60 0	6 6	8.0	803
Stanley Dock	51 0	5 8	7.0	753
Collingwood Dock.....	60 0	6 9	5.0	553
Salisbury Dock	60 &50	6 11	3.4	406
Clarence Graving Dk. and Basin	45 0	4 9	1.2	291
Clarence Half-tide Dock	50 0	5 6	4.3	635
Clarence Dock.....	47 0	3 2	6.0	914
Trafalgar Lock	45 0	6 7	0.3	256
Trafalgar Dock	45 0	4 11	5.9	764
Victoria Dock	40 0	4 11	5.7	755
Waterloo Dock	...	...	5.6	787
Waterloo Lock	45 0	6 5	0.7	256
Prince's Dock & Locks ..	45 0	5 11	11.8	1613
George's Dock & Passage	42 &40	4 6	5.5	1001
Manchester Dock	33 0	0 3	1.1	339
Manchester Lock	33 8	3 9	0.1	57
Canning Dock	45 0	6 1	4.1	585
Canning Half-tide Basin	45 0	6 3	2.5	429
Albert Dock	45 0	6 4	7.7	885
Salthouse Dock	45 0	6 0	6.4	784
Wapping Basin	40 &50	6 0	1.6	454
Wapping Dock	50 0	6 0	5.1	815
King's Dock	42 0	5 0	7.8	875
Basin to Queen's Dock..	70 &50	6 9	3.7	445
Queen's Dock	50 &60	6 0	10.3	1214
Coburg Dock	70 1	6 0	8.9	1053
Brunswick Dock.....	60 0	6 6	12.6	1086
Brunswick Half-tide Dk	42 &45	5 6	1.7	491
Toxteth Dock	40 0	5 0	1.1	393
Harrington Dock	29 9	1 2	0.8	315
TIDAL BASINS.				
Canada Basin	350 0	...	7.0	546
Sandon Basin	200 0	...	6.2	702
Prince's Basin.....	156 0	...	4.3	509
Seacombe Basin.....	52 0	...	0.4	188
George's Basin	147 0	...	3.3	455
George's Ferry Basin ..	70 0	...	0.3	160
Manchester Basin	36 0	...	0.5	288
South Ferry Basin.....	60 0	...	0.6	205
Harrington Basin	40 0	...	0.8	308

BIRKENHEAD DOCKS.	Width of Entrance.	Sill under Old Dock Datum.	Water Area.	Quay Space.
	ft. in.	ft. in.	acres.	yards
Wallasey P..West Float	100 0	12 0	52.1	3730
Ditto .....East Float	30 &30	9 0	59.4	3266
Ditto .....Passage	100 0	7 6	..	..
Ditto, Basin nr. Canada Works .....West	50 0	..	1.2	543
Ditto, ditto .....East	50 0	..	1.0	390
Ditto, R'way Co.'s Basin	..	..	0.1	113
Egerton Dock	70 0	7 0	3.4	754
Morpeth Dock	70 &50	5 3	3.1	790
Morpeth Enlargement ..	..	..	9.8	882
North Reserve Dock..	100, 50 & 30	12 0	8.2	2065
Low Water Basin	..	..	14.2	1323
Total when completed..	..	..	153.3	7 miles 1,530 yards
LIVERPOOL CORPORATION DOCKS.				
River Craft Dk., Lock, and Eagle Basin....	..	..	..	..
Outer Gates.....	80 0	0 3	1.3416	..
Inner Gates.....	80 0	1 3		
Duke of Bridgewter's Dck Outer Gates.....	40 0	..	..	..
Middle Gates	28 10	0 6	2.1336	..
Inner Gates.....	40 0	..		

LIVERPOOL GRAVING DOCKS.	Width of Entrance.	Sill under Old Dock Datum.	Length at Bottom.
	ft. in.	ft. in.	yards
Canada Lock & Graving Dock	100 0	7 9	..
Huskisson Lock & Graving Dk	80 0	6 6	..
Sandon Graving Docks, No. 1..	60 0	3 6	180
No. 2..	70 0	3 6	180
No. 3..	60 0	3 6	180
No. 4..	70 0	3 6	180
No. 5..	45 0	3 6	180
No. 6..	45 0	3 6	180
Clarence Graving Docks—			
No. 1—Outer Gates..	45 0	3 0	135
No. 1—Inner Gates..	45 0	0 6	97
No. 2—Outer Gates..	45 0	3 6	138
No. 2—Inner Gates..	33 0	0 6	96
Canning Graving Docks—No. 1	36 0	+1 8½	147
No. 2	36 0	0 0	160
Queen's Graving Docks—No. 1	42 0	1 8	146
No. 2	70 0	3 6	145
Brunswick Graving Dks—No. 1	42 0	2 6	133
No. 2	42 0	2 6	133

	Acres.
Area of Docks and Basin at Liverpool	251.5
Ditto ditto Birkenhead	153.3
Total	404.8

	Miles.
Length of Quay space at Liverpool	18.4
Ditto ditto Birkenhead	7.1
Total	25.5

NOTE.—The Old Dock Sill is the Datum to which all the Depths of Sills and Tides on the Mersey are referred. This Datum is 4.75 feet below the Ordnance Datum, or Mean Half-tide Level at Liverpool.
The Area of Docks is only given to the nearest fraction of an Acre. Some of the Works at Birkenhead were not completed in January, 1862.

RESULTS OF TIDAL OBSERVATIONS AT LIVERPOOL,

Taken through the Years 1818-19-20 and 21.

	ft. in.	
Average High Watermark of Spring Tides	18 3	Ab've Old Dock Sill.
Ditto next ditto, or Equinoctial Spring Tide	20 0	
Ditto next ditto, or ditto	23 0	
An extraordinary Equinoctial Spring Tide, April, 1821	23 0	
An extraordinary ditto, as marked on Leasowes Lighthouse	25 0	
Average High Watermark of Neap Tides	11 3	
Highest ditto	18 6 to 14 0	
Lowest ditto	9 3	

	ft. in.	
Average Low Watermark of Spring Tides	8 9	Bel'w Old Dock Sill.
Highest ditto	6 6	
Lowest ditto	11 0	
Average Low Watermark of Neap Tides	1 9	
Lowest ditto	4 6	
Highest ditto	1 0	Ab've ditto.
Mean Tide Level, Ordnance Datum	4 9	

TABLE OF DIMENSIONS OF DOCKS,

Depths of Water over Sills, Area of Water Space, &c. &c., of some of the principal Establishments in the United Kingdom.

NAME OF PORT AND OF DOCK.	Date of Commencement.	Dimensions of Wet Dock.			DEPTH Over Sill.				Width of Entrance.		If Entered by Lock.			
		Area of Water Space.	Length	Brdth	At High Water Spring Tides		At Low Water Spring Tides.				Length		Brdth.	
		Acres	Yards	Yards	Ft.	In.	Ft.	Ins	Ft.	Ins.	Ft.	Ins.	Ft	Ins.
HARTLEPOOL.														
Victoria Dock	1832	20½	645	160	22	0	6	0	45	0	148	0	45	0
W. Harbour Dock	1844	7	258	126	21	6	5	6	42	0	..		..	
Ditto Extension	1850	8½	310	132	23	6	7	6	50&60		..		..	
SUNDERLAND.														
Wearmouth Dock	1837	6	183	165	20	3	5	6	50	0	90	0	70	0
Sunderland Dock	1850	19	645	147	20	6	6	0	60	0	..		..	
LEITH.														
East Dock	1800	5½	250	100	17	6	0	0	36	0	160	0	36	0
West Dock	..	5½	250	100	..		..		36	0	..		..	
New Dock	1848	5	233	100	19	0	8	0	60	0	..		..	
DUNDEE.														
William IV. Dock	1815	6½	240	126	15	6	0	0	40	0	150	0	40	0
Earl Grey Dock	..	5½	180	140	18	0	2	6	55	0	210	0	55	0
Victoria Dock	1833	14½	430	170	21	0	5	6	60	0	230	0	60	0
MONTROSE.														
Dock	1839	3½	150	106	19	0	3	6	55	0	..		..	
ABERDEEN.														
Victoria Dock	1844	33½	950	175	21	0	10	0	60&70		250	0	60	0
DUBLIN.														
Royal Canal Dock	1789	1½	252	32	15	0	4	6	27	0	118	0	27	0
Old Custom House Dock	1770	2	139	72	18	0	..		36	0	..		..	
George's Dock	1770	1½	107	86	18	0	..		36	0	..		..	
Large Dock	1816	4½	217	100	18	0	..		36	0	180	0	36	0
Grand Canal Dock	1793	24½	1005	120	18	0	7	6	35	6	150	0	35	6
GALWAY.														
New Dock	1833	7½	239	193	16	0	1	0	56	0	..		..	
LIMERICK.														
Dock	..	7½	270	130	22	0	..		50	0	..		..	
CORK														
North Dock	..	6	..	..	18	6	6	0	45	0	180	0	45	0
South Dock	..	12	..	..										
BRISTOL.														
Cumberland Basin	1804	4½	245	90	30	0	0	7	54&45		260		54&67	
Bathurst Basin	..	2	140	70	..		0	9	35	8	152	0	..	
Floating Harbour	..	63½	1800	85	30to34		..		45&35		186 / 150		45 & 35	
PLYMOUTH.														
Great Western Dock	1847	13	420	150	24	0	6	0	80	0	250	0	55	0
NEWPORT.														
Dock	1835	4	270	73	25	0	25	0	61	0	225	0	61	0
CARDIFF.														
Bute Docks	1838	21	1333	66	19	0	19	0	36	0	152	0	36	0
SWANSEA	1849	12½	760	80	21	6	8	6	56&70		165	0	56	0
IPSWICH.														
Dock	1837	33	1120	140	16	6	3	0	45	0	150	0	45	0
GREAT GRIMSBY.														
Dock	1846	20	600	167	26	0	4	0	70	0	300	0	70	0
HULL.														
Old Dock	1774	10	567	84	18	0	2	9	38	0	121	0	38	0
Humber Dock	1803	7	300	110	24	0	5	0	42	0	158	6	42	0
Junction Dock	1826	6	214	140	..		..		36	6	130	0	36	6
Railway Dock	1845	2½	240	55	..		..		43	0	..		..	
Victoria Dock	1846	12½	480	126	25	0	6	6	50	0	120	6	32	0
Ditto Half-Tide Basin	..	3	110	115	25	0	6	6	60&32		120	6	60&32	
GOOLE.														
Barge Dock	1820	3	290	50	9	0	9	0	22	0	72	6	19	6
Ship Dock	1820	3½	234	67	17	0	17	0	29	6	119	0	29	6
Harbour Dock	1820	1½	87	67	17	0	17	0	33	6	72&119		22&33	
Steam Ship Dock	1836	4	120	164	19	0	19	0	58	0	210	0	58	0
Railway Dock	1847	2¾	200	67	19	0	19	0	58	0	210	0	58	0
STOCKTON.														
Middlesborough Dock	1839	10	400	130	19	0	5	0	30	0	132	0	30	0

MANUAL OF HYDROLOGY.

DIVISION IV.

ON

RAINFALL AND EVAPORATION;

WITH

TABLES OF RAINFALL,

AND

DISTRIBUTION OF RAIN,

&c., &c.

N.B.—Depths of rain and amount evaporated are always expressed in English inches; generally abbreviated "in."

DIVISION IV.—RAINFALL AND EVAPORATION.

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Glasgow, Greenock, Thurston, Millfield, Callton Mor, Balfour, Pittenweem, Trinity Gask, Easdale, Tyndrum 306
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DIVISION IV.

RAINFALL AND EVAPORATION.

REMARKS ON RAINFALL.

It is not the object of this treatise to discuss the subjects of Rainfall and Evaporation as meteorological questions, but rather as engineering facts, on which to found data for estimating the supply of water likely to be obtained, the force to be acquired, the volume of flow to be expected, the drainage to be carried off, or the flood to be encountered.

The matter contained in this part of our treatise will therefore be applicable only when used with due regard to the conditions of surface slope, geological formation, evaporation of the climate, concentration or distribution of rain, and other conditions of the wind and temperature. To elucidate these effects, the treatise on rivers and flow, in the preceding division, is drawn up with an endeavour to throw some light on the practical results of the meteorological phenomena of rain and evaporation.

Dealing with apparently the most capricious of all the elements, we nevertheless find a tolerable certainty of averages, and we may be sure that if we were fully acquainted with the law of distribution of moisture we should find that it varies with the climate and latitude in far greater regularity than our knowledge can yet carry us. It being therefore our wish to lay before the engineer or student facts rather than theories, we have collected the records of rainfall from all parts of the globe, as given in the subsequent pages; for a description of the series it will be more suitable to refer to the table of contents of this division.

Generally, the plan of giving simply each month's rain has been adopted, but at many places in Great Britain and its colonies there is also added the greatest fall in one day, and occasionally the evaporation.

The Tables commence with one shewing the rain at many important places in this country averaged over a stated number of years, with the maximum and minimum quantity for those periods. Each year is formed of three periods of four months each—commencing with November, December, January, and February, for the winter division; March, April, May, and June, for the spring division: July, August, September, October, for the summer division; each year being made up of these periods, instead of the customary twelve months.

This plan of division is adopted because, for purposes of comparison, it gives the rainy seasons of these seaboard latitudes in better arrangement than the ordinary division into months; for instance, a wet November and December are not unusually followed by a dry January and February, and *vice versâ*. To expect, therefore, a small discharge in March because the fall of rain may be small in the two preceding months only, would be calculated to lead into error. Moreover, the amount of deduction for evaporation, and especially absorption, will arrange itself more systematically under these divisions.

The table succeeding the above, pages 300-1, is constructed from good specimens of the hill and the low country of Great Britain.

Glencorse is a deep valley in the Pentland Hills, 10 miles from Edinburgh, where observations have been kept by the Water Company since 1830, at the level of their springs near the lowest point of the basin. The hills rise precipitously all round to heights of 1,200 to 1,600 feet above the sea, and are about twelve miles from the Firth of Forth.

Gilmourton is in a valley of flatter character, with the Avondale moors rising to 1,600 feet, at two to five miles distance in the south and west direction from the gauge—the hills are twenty miles from Glasgow, and the same distance from the west coast of Scotland.

The Boston observations are well known to represent the steady character of weather of the low country of Eastern England.

In this Table the object has been to shew in juxtaposition, the amount of rain falling in quantities so heavy as to begin affecting streams, and the total amount given by the rain-gauge during each month. The minimum quantity, taken as "heavy rain" falling in each twenty-four hours, is .3 inch. The average number of days in the months and years in which the rain per diem equalled or exceeded this, is also given in the Table.

It will be at once seen, by those familiar with the subject, that this mode of arrangement indicates an amount probably available for streams, not at all unlike the result of experiments: whether so small a fall as three-tenths of an inch will influence the flow must depend on the season and previous state of rains.

In September or October in a dry year in these latitudes, it takes an inch of rain repeated twice in one week materially to affect streams, unless the country is precipitous and hilly. Even in such a district as the Arve, draining the vast precipices of Mont Blanc, it takes a week of the first autumnal rains to produce much effect on the river.

In tropical and semi-tropical countries, these remarks have no application; the rain always falls much more heavily, and between the rains the earth dries up and cracks open in a manner not appreciable in moist climates. The probable consequence of this is that far more water is absorbed for vegetation and upward exosmose, for the fissures admit the rain to such a depth as to preserve it from the direct action of the sun and wind.

The tables devoted to rainfall of Great Britain, contain the details of several important stations in different parts of this country; from pages 336 to 347, standard observations, over a long series of years, are given in periods of four months. We have also selected the rains of the years 1852 and 1860, as being remarkably wet in many parts of Great Britain; and with the rainfall we have given the number of days rain, in order to shew the mean intensity. The heavy falls of rain between 1837 and 1858 at Greenwich,* are given from Mr. Glaisher's labours, with the object of shewing the intensity of rain in this climate. See pages 310 to 315, 318, 324, &c.

In reflecting upon his sources of water, the engineer must regard the ocean as the great fountain of supply. At the periods of the year when rains are copious they are always carried by winds from the sea with an ordinary velocity of from 20 to 30 miles per hour, so that the range of territory within reach of precipitation from sea breezes is very great. If mountain chains intervene, these winds are divested of their vapour to a great extent, so that the interior continent has a drier climate in pro-

* The first five years of the Greenwich rainfall, 1820 to 1824, at page 342, are doubtful from some disturbing cause; the returns do not accord with those taken in the neighbourhood: they are too large.

portion to what it would have if the mountains had not existed. As an example, we find that the lake district of England is unusually wet, but the high moor country round Newcastle, at some distance to leeward, has a dry climate. Owing to the same causes, the Rhone and the Po carry a larger volume of water than the Rhine or the Elbe; and the plains of Germany have a small rainfall, which is generally more evenly distributed. In short the great precipitation in countries subject to winds from the sea, disappears as the same winds are carried so far inland as to have parted with their surplus vapour. There are of course exceptions to this rule, even in the case of mountains; those for instance of New Mexico and the secondary or interior ranges of Palestine, and likewise those bordering upon the Caspian, appear not to be productive of rain; manifestly because the winds of the ocean cannot reach them until they have lost their moisture on anterior ranges. We know, in proof of this, that the Circassian Mountains and the hills of Jerusalem, and the Pacific coast, all have prolific rains; yet if such rains were to extend over the basins of the Caspian or Dead Sea, or the Great Salt Lake, or the sources of the Arkansas and Missouri, these receptacles of surplus waters would be entirely altered in physical character, and the rivers would have such immense volumes as to render their floods of a stupendous character. There must be in all countries at any distance from the coast a certain limited proportion of the rainfall, which proceeds from re-evaporation of rain which has watered the antecedent territory: analogy would lead us to believe that this is a more constant or regular quantity than the capricious and variable supply from the ocean itself; but at the same time, it must vary with the amount previously deposited, and therefore follow the original rain, but in a less degree. If this theory be correct, we may regard the minimum years of rain belonging to interior Continental localities as indicative of precipitation due to re-evaporation alone; years of greater rainfall receiving their additional supplies of rain from a preponderance of winds from the ocean.

We believe these to be the principles which determine the distribution of rain, subject nevertheless to many other conditions, which are baffling to those who attempt to discover prime causes: thus the warmth of the ocean depends on causes excited at great distances; for instance, the temperature of the gulf stream, which undoubtedly washes the western and northern shores of these islands, is due to the warmth of the tropics; on the other hand, the climate of the land is influenced to a greater extent by radiation, owing to the non-conducting power of the substratum.

We are liable, in the temperate climate of these islands, to the influence of a vertical sun, transferred during the fall of the year, by the natural currents of the ocean; this medium for conveying a high temperature is at any moment liable to be covered by winds which may convey the cold of northern glacier and ice-fields to our climate within a few hours. For instance, it is not likely that the gulf stream travels from the Equator to our latitudes at greater rate than 24 to 30 miles per diem, requiring 150 to 160 days for travelling the distance: but an ordinary wind can range over the same distance in 4 to 6 days, or can reach us from the northern latitudes in half that time.

To these exciting causes we may look for the heavy rain storms of May and October, the fogs of November, and the copious rains which generally accompany some one or more of the winter months in these latitudes; placed as they are so as to form the battle-field of heat and cold, which are the contending positive and negative elements of the regenerative powers of the earth.

RAINFALL AT DIFFERENT HEIGHTS ABOVE THE GROUND.

For engineering purposes, and indeed for any really philosophical inquiry, it is always most desirable to have a strict knowledge of the amount of rain which reaches the ground; if, therefore, the rain gauge has been observed at any given height above the ground, the result will have to be increased, in order to obtain the real amount which would have fallen upon the ground itself. Mr. Henry Storks Eaton, M.A., has recently investigated this subject by averaging a great number of places in this country, where gauges have been observed simultaneously on the ground and at different heights above it. The details will be found in a paper by this gentleman in the Proceedings of the British Meteorological Society for November, 1861. Mr. Eaton remarks that "in investigating the rainfall of any district, two points have to be determined before the results are strictly comparable. The indications obtained by observation must be reduced to some common standard, both as regards the series of years during which observations have been made, and the elevation of the gauge above the ground.

"It is a well-established fact, that the amount of rain registered by a gauge decreases as the height above the ground increases. No very satisfactory explanation has hitherto been advanced for this singular phenomenon. Some attribute it to the action of the wind producing an eddy in the funnel of the gauge, whereby the rain is either swept out or prevented from entering; others suppose that the cold rain-drops in falling condense the circumambient vapour on their surface: but that recently proposed by Mr. Baxendell, of Manchester, seems the least objectionable; he imagines that particles of water which have lost the caloric of elasticity are capable of existing in the atmosphere in an invisible state, and that the rain-drops collect these in their fall. The fact of the decrease, however, is undisputed; and to obtain an approximation to the actual value, the records of the Meteorological Society, and the tables furnished by private observers, have been called into requisition; the results are given in the following table, from which it will be seen that, taking the rainfall at the surface of the earth as equal to 1,000, at 50 feet above the ground it is .775 of that quantity."

Table of divisors in column B, to be used for increasing the quantity of rain observed at any given height above the ground in column A, so as to make the observed quantity of rain equal to that which would have fallen on the ground in the same place:—

A. feet.	B. div.	A. feet.	B. div.	A. feet.	B. div.	A. feet.	B. div.	A. feet.	B. div.
1	.993	11	.927	21	.876	31	.835	41	.801
2	.986	12	.921	22	.871	32	.831	42	.798
3	.979	13	.916	23	.867	33	.827	43	.795
4	.972	14	.911	24	.863	34	.824	44	.792
5	.965	15	.906	25	.859	35	.820	45	.789
6	.958	16	.901	26	.855	36	.817	46	.786
7	.951	17	.896	27	.851	37	.813	47	.783
8	.945	18	.891	28	.847	38	.810	48	.780
9	.939	19	.886	29	.843	39	.807	49	.778
10	.933	20	.881	30	.839	40	.804	50	.775

Observers cannot be too particular in selecting a position for rain gauges, evaporating dishes, or wet bulb thermometers; unusual currents of wind are easily excited or prevented, and if this occurs, what is apparently very inappreciable, will cause the results to be more or less abnormal.

ON THE TABLES OF MOUNTAIN RAINFALL.

Among the practical applications of Meteorology, one of the most useful to an engineer is that relating to the fall of rain; for upon it depends the supply of the most necessary of elements, one of the most fertilizing, and at the same time one of the most destructive of meteorological agents. In these days, when manufactories and populations increase so rapidly, rivers are frequently consumed for mill and steam power, or spoilt by contaminations; for these reasons the collection of water for artificial distribution has become a great branch of engineering. It has been long known that high mountains, especially when exposed to a seaward aspect, are watered by an abundant deposit of rain; but the enormous amount of this rain within certain limited belts in such districts was not so accurately known until the researches of the Swedish meteorologist Schow, and our own acute observer, Colonel Sykes, F.R.S., threw a light on the subject.

Having reference to the variable character of the rainfall in mountain districts, we have a development of the same law of *decrease* of rain as we ascend very precipitous elevations, which appears to prevail when we elevate the rain gauge directly above the ground; notwithstanding that, *cæteris paribus*, the rainfall *increases* as we rise up the slope of a mountain.

For instance, in the rainfall of France will be found records of rain kept at Besançon, 1,200 feet above the sea, where the mean rainfall was 44.2 inches, and at Fort Brégille, 600 feet higher, the quantity was only 25 inches on three years' average. Very similar anomalies occur in comparing observations on the rock of Edinburgh Castle, with others taken at points in the locality about 400 feet lower.

It is much to be desired that the law could be ascertained which would give an approximation to the increase of rainfall as we ascend hill country; to obtain this it would be necessary to observe at a great number of stations thickly placed on given ranges of hills.

We have placed among the tables the most extensive collections of this kind available; among others will be found observations kept by the Edinburgh Water Company at several points on the Pentland Hills, which have been very kindly supplied by Mr. Ramsay, the able manager of the company. See pages 319 to 329.

Colzium, the extreme westerly station is 1,030 feet above the sea on the north-western slope of hills which rise above it to about from 1,200 to 1,600 feet above the sea. Glencorse, 735 feet above the sea, is on the leeward of the eastern slopes of the same range of hills about 10 miles from Colzium. Harelaw, 876 feet above the sea, is situate 5 miles east of Colzium on the north-west slopes, but projecting more northerly than Colzium. Swanston, 550 feet above the sea, is about 3 miles due north of Glencorse, on a projecting spur of the same hills. With this explanation we leave the tables for the examination and analysis of the reader; but will take the opportunity of alluding to a remarkable feature of the year 1852, which was a very wet year in this part of Scotland, as it was in the Cumberland mountains, and in the south of England. In this latter district, November was pre-eminently the wettest of the five wet months from August to December; but it was in December that the extraordinary outpouring of wet was developed in North Britain and the Cumberland Mountains. This will be seen by comparing the table in question and those of the mountain rainfall of Cumberland with the details of the year 1852 throughout England. This kind of progression in the period of greatest rain is not singular, and may be seen on comparing the rainfall of other years for stations placed at great distances apart, as referred to in the article on the Po, Division II.

It appears that at Bombay the mean of 33 years' rainfall (April to November) is 76.8 inches at 20 feet above the sea, while the rain for 21 years at Mahabuleshwur 130 miles inland, and 4,500 feet above the sea, is 253 inches; but this amount is rapidly reduced when passing eastward of the Ghâts, for within a few miles distance there were only from 70 to 80 inches, and finally the Deccan (or dry country) has a rainfall of from 16 to 20 inches per annum.

Among the tables will be found the rainfall for three years, 1858-9-60, which gives a kind of section across from east to west of England between Manchester and Grimsby; it has been kindly placed at our disposal by Mr. Robert Smith, the manager of the Sheffield and Lincolnshire canals. The relative heights of the stations shew very clearly the influence of elevation over the Penine chain, and the gradual reduction of moisture as we descend eastward to the low country of Lincolnshire.

There will also be found a similar kind of rain section from the north of the Alps at Geneva to St. Bernard, Turin, Florence, Rome and Naples; this section may be extended into Germany, by referring to the rain tables of that country.

Probably a more just notion of the manner in which rain is collected in a hilly country will be found in the tables of actual flow from large districts, where we have the result of the rain gauge, diminished by the amount of evaporation. We may here find a flow of from six to nine inches in depth off a low country in a year, and from 51 to 111 inches off a district entirely mountainous, but of one-sixth the area of the former.

The district of the Bann, which includes both mountain and low-land, gave nearly 22 inches in 1856; the mean of many years' flow of the Tiber, at Rome, is also 21.62 inches. The basin of the Saône, 11,557 square miles, gives generally from 20 to 22 inches; one-half of this area is the dry country of Burgundy, but the higher portion is formed by the Jura and Vosges mountains; if one-half gives six inches of flow per annum, the mountainous portion will give 36 inches, so that the maximum precipitation at the vapour plane of this area, must be very considerable. The Rhone, at Geneva, appears to give a mean flow of 48.24 inches off its 3,000 square miles of area; the Arve, which is still more exclusively mountainous, gave in 1856 about 78.72 inches off 772 square miles, an amount nearly accordant with the quantity gauged off the Grampians.

According to Vignon, the depth of rain is about 60 inches in the basin of the Cure at Montsauche, an affluent of the Yonne. The height is 1830 feet above the sea; the mean annual flow of the river is .75 of this rainfall.

Lombardini considers that the mountainous part of the basin of the Po gives a mean annual flow equal to 47 inches of rain over the surface: if this flow be three-fourths of the annual rainfall, the average rain over the mountains must be equal to 63 inches. Having relation to the discharge of the Alpine rivers, Adda, Ticino, and Dora Baltea, the rain on the mountains must be 94 inches, 122 inches, and 138 inches respectively; from these results Lombardini concludes that in the Alps the rainfall must be four times that on the plains of Lombardy.

The results are consistent with the elaborate researches on the climate of the Alps, by Schow.

The late Mr. Miller, of Whitehaven,* made a series of observations on

* It is not generally known that the expense of Mr. Miller's observations was defrayed by annual subscriptions from several engineers and other gentlemen, interested in the investigation; the facts developed were previously quite unknown. Dr. Dalton certainly does not appear to have had any idea of the immense rainfall of the seaward valleys of the Cumberland Mountains.

the mountain districts of Cumberland, which have been reported in great detail in the Transactions of the Royal Society; his results give about 46 inches of rain at 250 feet above the sea; *i.e.* from 40 inches for a dry year to 55 inches for a wet one. The deep valleys up to 1,000 feet above the sea had from 130 to 160 inches; but higher up the precipitation was less; at points 930 to 1,340 feet above the sea level, it was 90 to 130 inches; and again, at 3,000 feet above the sea, the fall was reduced to an average of from 76 to 84 inches.

On the west coast of Scotland, again, we have at Glasgow rainfall of from 24 to 36 inches near the level of the sea, while at points of the Grampian mountains 1,800 feet above the sea, the records range from 70 to 109 inches of rainfall. Some of the Western Highlands and Islands have a prodigious rainfall; it is partly due to this, probably, that the wild and rocky mountains of the coast have gathered no superficial earth on their slopes, in the ages elapsed since their elevation from the ocean bed. The rain at Tyndrum is indicative of what the precipitation may be near the mountains; at this place 133.2 inches of rain fell in 1861; and at Portree in the Isle of Skye, there was a fall of 139 inches in the same year.

These facts, which we have here put in a general way, form the basis of water supply to our mountain rivers, and it is on such sources that the most effective reservoirs must be formed, so as to retain the rain, which in high localities is as capricious, and falls if anything in a more concentrated form, than in low districts having comparatively small rainfall. There is one fact, however, apparently inseparable from localities near the line of saturation, viz.: that the climate is invariably moist and springs are perennial.

The tables given under the head of Mountain Rainfall, and on other pages, will shew the several facts herein referred to. The point of maximum rain depends on the mean height of the plain of condensation, or mean cloud level, which may be calculated if the prevailing meteorological condition of the locality be properly ascertained. The mountains in Cumberland produce great rains at low elevations; the rainfall at Seathwaite, at 368 feet above the sea, is 138.5 inches on an average of seven years, and on the Stye at 748 feet above the sea, there are only 20.6 inches more rain, the total being 159.1 inches; in 1861 the fall amounted to 182.6 inches at Seathwaite.

In the Cumberland mountains the amount of fall in one day is marvellous for such a high latitude: on seven years the maximum daily fall of each month makes a total average of twenty-eight inches in a year, which is, in other words, an average maximum fall in twenty-four hours for each month in the year, of 2.33 inches; the maximum day's rain having been 6.22 inches. See pages 322 and 324.

In Devonshire the rain on the coast varies from 25 to 40 inches; on Dartmoor, say 1,100 to 1,400 feet above the sea, the rainfall is from 58 to 75 inches; the following tables give the amount registered at Holne Vicarage, about 690 feet above the sea, on the lee side of Dartmoor;—

In November, 1850, 5.59 fell in the week, from the 17th to the 23rd.

In January, 1851, there fell in the following weeks:—

1st to the 4th	... inches	4.42	19th to the 25th	... inches	6.11
5th to the 11th	... ,,	2.96	28th to the 31st	... ,,	4.45
12th to the 19th	... ,,	3.94	On the 20th.	... ,,	4.17

On the 6th Nov., 1852, 3.91 inches fell, in the night; the fall this month was—

1st to the 6th	... inches	7.36	21st to the 27th	... inches	4.94
7th to the 13th	... ,,	2.68	28th to the 30th	... ,,	0.37
14th to the 20th	... ,,	5.82	12th to the 18th Dec.	,,	6.30

RAINFALL AT HOLNE, DEVON.

	1851.	1852.	1853.	1854.	1855.	1856.
January	21.88	19.98	12.42	14.46	0.42	11.25
February	3.89	3.97	5.00	1.75	4.54	7.30
March	12.54	2.70	2.56	1.73	5.09	3.95
April	3.63	1.85	4.61	0.78	1.35	9.35
May	2.32	4.74	2.15	5.68	4.16	6.09
June	5.80	10.52	5.81	5.18	6.44	2.49
July	7.40	0.65	5.18	2.27	4.90	1.67
August	4.17	6.43	6.17	2.32	2.56	3.75
September	2.24	3.24	3.78	1.81	1.27	5.39
October	5.88	11.58	11.59	5.33	8.79	4.89
November	2.44	21.17	6.87	4.85	1.96	1.30
December	5.73	15.70	6.69	4.51	6.82	9.17
Inches	77.92	102.53	72.83	50.67	48.30	66.60

MOUNTAIN RAINFALL OF THE INDIAN PENINSULA.

The following is from Col. Sykes's description of his records of Mountain Rainfall in the Indian Peninsula, of which we have printed an abstract in the tables of Indian rainfall.

In the table of rainfall of India, we commence at Bombay, and pass over the Ghâts into the Deccan. The sanitarium at the summit of the Ghâts is about 130 miles from Bombay, while Sindola is only one mile eastward, Sattarah being about ten miles east of the summit of the Ghâts, and Phultun forty miles.

Of the three stations on the Tinnevelly or Coromandel Coast, Shenkottah is near Courtallum, immediately at the east base of the Ghâts, and about sixty miles from the sea coast of Travancore; Palemcottah is about thirty miles from the east base of the Ghâts, is sixty miles from the western coast, and in the latitude of Quilon; Vaurioor is only three miles north-east of Cape Comorin. The western and eastern stations are separated by the Ghâts which in some places rise to a height of 6,000 feet, but within ten miles of Cape Comorin they break off into separate groups and peaks of much less height. Dodabetta is part of the Neilgherries and the highest point of the Peninsula of India. Mahabuleshwur, Mercara and Uttray Mullay, at the common level of 4,500 feet, are nearly in the same meridian, but between 9° and 18° north latitude, and are situated near to the western scarp of the Ghâts.

In the district between the sea-shore and the base of Ghâts between Cape Comorin and Goozerat, and along the western face of the Ghâts, the rain increases with the elevation up to a certain height, after which it again diminishes with increased height. This does not hold good, however, on the elevated lands to the eastward of the crest of the Bombay and Malabar Ghâts. Along the sea-coast the falls vary from 28.35 inches at Cape Comorin to 113.26 inches at Allepy, but increase at stations nearing the Ghâts, at different elevations to more than 300 inches at 4,500 feet, above which height the falls gradually diminish in quantity.

Mean of 7 stations western coast, at sea level, is...	81.70	inches.
At 150 feet, Rutnagberry, in the Concan ...	114.55	,,
At 900 feet, Dapolee, Southern Concan	134.96	,,
At 1,740 feet, Kundalla Pass	141.59	,,
At 4,500 feet, Mahabuleshwur, mean of 15 years	254.05	,,
At 4,500 feet, Mercara in Coorg, mean of 3 years	143.35	,,
At 4,500 feet, Uttray Mullay, in Travancore ...	263.21	,,
At 6,100 feet, Kotergherry, on the Neilgherries ...	81.71	,,
At 8,640 feet, Dodabetta	101.24	,,

Hence the elevation of the line of maximum fall would appear to be about 4,500 feet, and above this level the supply of rain is diminished. Mahabuleshwur, Mercara, and Uttray Mullay, although differing greatly in latitude, lie nearly in the same meridian, and are all at the same elevation. The comparative small fall at Mercara is accounted for by the fact of its not being so near the western scarp of the Ghâts as Mahabuleshwur and Uttray Mullay. The effect of a station being placed a few miles east of the Ghâts upon the fall of rain is shewn on comparing Mahabuleshwur with Paunchgunny, the latter place being 11 miles eastward of the former and at a lower level of only 500 feet; yet the mean fall of 15 years at Mahabuleshwur was 254.05 inches, and of the latter 50.69 inches. In 1849, the contrast was still greater, the fall at Mahabuleshwur amounting to the enormous quantity of 338.38 inches, while at Paunchgunny only 58 inches fell.

The chief stratum of aqueous vapour brought from the equator by the south-west monsoon is of a high temperature, and floats at a lower level than 4,500 feet; Col. Sykes speaks of looking over or upon the upper surface of the stratum at 2,000 feet. It is dashed with considerable violence against the western mural faces of the Ghâts, and is thrown up by these barriers in accumulated masses into a colder region than that in which it naturally floats; it is consequently rapidly condensed, and rain falls in floods. The uncondensed vapour which escapes up the chasms and over the crest of the Ghâts affords the precarious and scanty supply to the lands to the eastward, shewn by the tables.

ON THE INTENSITY OF RAINFALL IN INDIA.

As might be looked for, the greatest fall of rain in any one day, is met with in the records of those stations where there is the greatest annual fall. At Mahabuleshwur the greatest fall in any one day in 15 years was 13.06 inches on the 2nd September, 1833, but the months of June, July and August, have numerous instances of a daily fall of 11.32 inches, 12.76 inches, and 12.69 inches in those months respectively. The greatest monthly fall at Mahabuleshwur was 134.42 inches in July, 1840. At Uttray Mullay the greatest daily fall in three years was 15.1 inches on the 14th October, 1845. On the 11th December, the same year, there was a fall in one day of 11.4 inches, and on the 9th October, 1844, the fall in one day was 9.0 inches. In 1846 there was not a daily fall approaching these figures. In Bombay, in 1845, the greatest daily fall was 4.71 inches on the 24th July, and the next year, on the 16th July, a daily fall occurred of 5.16 inches; but Dr. Buist mentions that on the 1st July, 1844, there was a fall of rain in 24 hours of 7.44 inches, 2 inches having fallen in 70 minutes; but this was on the first burst of the monsoon, which set in later than usual by three weeks; on the 10th July 9.43 inches fell, the greatest of the year. In the Deccan there is rarely a greater daily fall than 2 inches, but in the Sattarah records, a maximum daily fall of 4.40 inches in four years is stated to have occurred in April, at the commencement of the monsoon.

It is found both on the sea coasts and on the table lands of the Deccan that within very limited areas the differences in the fall of rain may be very great. With nine rain gauges, employed in the small island of Bombay, in the months of June and July, in the monsoon of 1849, the quantity collected in the different gauges ranged, in July, from 46 inches to 102 inches, and in June from 19 inches to 46 inches. At Sattarah, with three rain-gauges within the distance of a mile, they differed in their contents several inches from each other, and at Mahabuleshwur and Paunchgunny, nearly on the same level, the latter place being only eleven miles to the eastward of the former, the difference in the annual fall of rain was respectively 254 inches and 50 inches! The normal conditions are, that there is a much greater fall of rain on the sea coasts than on the table-lands of the Deccan, but that the Ghâts, intervening between the coasts and the table-lands, have three times the amount of the fall on the coasts, and from ten to fifteen times the amount of the fall on the table-lands of the interior. The paucity of the fall of rain at Cape Comorin and the mouths of the Indus would also appear to be a normal condition; this also occurs in the Red Sea; at Aden, for instance, the rain only falls once in two or three years, although there is an abundant supply on the hills within sight of the fort. At Kurrachee, it is well known that the moisture is only in the form of dew. Rain certainly does not fall more frequently than at Aden.

Mr. Eaton makes the following remarks on the distribution of rain:—

The position, height, and direction in which mountain ranges extend, materially affect the deposition of rain over wide regions. Where ranges of mountains trend from north to south in the tropics, the prevailing easterly trade winds deposit a large fall of rain on their eastern slopes; to this cause may be attributed the vast rivers in tropical South America, which have their origin in the lofty Andes: on the western side of these mountains, in Peru, rain very rarely falls.

In extra-tropical regions the normal direction of the wind is from the west, and the principal fall of rain is on the western face of the hills: for instance, the Andes of Patagonia, the Rocky Mountains in North America, and the Scandinavian chain, are all well watered on their western faces; while the country lying on the other side of these ranges is but scantily supplied with water.

It must not be forgotten, that where great condensation takes place the wind has a tendency to blow from all quarters towards that point: mountain ranges, however, often modify this law. In India, for example, the rains which attend a vertical sun are intensified by the action of the great barrier of the Himalayas; but as these mountains prevent an influx of air from the north towards the area of condensation, and consequent expansion from the development of latent caloric, the comparatively cool air over the Indian Ocean flows in as a strong monsoon to an abnormally high latitude. Among the Polynesian Islands, where the mountains occur as isolated peaks, the wind, in the rainy season, is invariably found blowing towards the point of greatest condensation.

On the open ocean the fall of rain is generally much less than it is in the vicinity of land, excepting, perhaps, near the equator, and where cold and warm currents of water occur in close proximity, as off Newfoundland. Two districts, however, have been indicated as regions of nearly constant precipitation—the belt of ocean to the south of Cape Horn, and the North Pacific, near Behring's Straits: in both places the excessive precipitation keeps the barometer about an inch below the general average of the whole ocean.

ON THE CHARACTER OF RAINFALL IN AUSTRALASIA.

Australia is a country of irregular rains in every respect. Generally the summers are hot and dry, and the evaporation is excessive; the heaviest rains are dried up rapidly, and produce no other effect than to fill up the cracks in the soil or to produce stupendous floods. Rivers in that country, with flat open plains for their water-courses, are known to rise 25 feet; and there are places where some of the rivers rise from 60 to 80 feet vertically. For example, the year 1801 appears to have produced a stupendous flood on the Hawkesbury River; but this was nearly equalled by one in 1806 (spoken of as the great and memorable flood), when the water at Windsor rose 97 feet above ordinary level. Jevons remarks that, considering the banks are about 30 feet high, and wide flats extend on each side, the statements appear incredible; but it must be true, for repeated testimony speaks of these floods attaining an immense height. In 1816, June 2nd, the height was 85 feet, "within 12 inches of the height of August, 1809."

These extreme floods, like the droughts, follow long periods of rest, during which the droughts are extreme. Many of the rivers of Australia at some periods form a succession of lakes, which last for a considerable time, but gradually disappear by the process of evaporation, after which the beds remain dry for several years continuously. This fact gives rise to the extensive salt plains of the interior, and generally to the desolate character of large breadths of the continent. The Murray river, however, rises like the Nile, being lowest in July and highest in December, the difference being about 17 feet; it appears to drain mountains which are exposed to periodic rain-winds from the eastern coast.

MEAN MONTHLY RAINFALL OF AUSTRALASIA.

Mr. W. S. Jevons, of Sydney, has written an interesting sketch of the climate of this country, from which we quote:—

Localities.	York, Western Australia.	Adelaide.	Port Phillip.	Launceston.	Hobart Town.	Sydney, City.	Sydney, South Head.	Port Macquarie.	Auckland.	Wellington, New Zealand.
Months of Observation.	12	75	134	36	144	36	189	144	12	27
January	.01	.37	1.76	1.15	1.17	2.57	4.31	10.32	.36	1.41
February	.25	.71	1.66	.54	1.07	3.44	3.95	7.39	1.20	1.82
March	5.46	.78	1.32	3.30	1.24	4.01	4.35	7.53	1.55	3.23
April.....	.13	1.62	2.85	1.95	1.57	5.25	6.29	8.52	4.49	1.82
May	2.59	1.72	3.48	3.55	1.57	7.11	5.10	8.07	1.97	3.23
June.....	7.71	2.39	1.97	3.62	2.00	3.93	5.24	4.73	3.10	3.92
July	4.34	2.31	2.20	3.89	2.27	3.39	4.66	4.34	4.82	5.90
August.....	3.11	2.73	2.85	3.22	1.55	1.94	3.18	4.49	2.50	3.80
September ...	.28	1.90	2.90	2.78	1.89	3.16	3.07	3.66	3.70	4.26
October.....	.45	1.89	2.68	2.50	1.52	3.09	4.33	4.27	4.50	2.37
November ...	.67	1.03	3.57	3.69	3.55	4.56	2.34	2.99	1.64	2.74
December ...	.39	1.76	1.92	1.72	.90	3.16	3.28	4.48	.81	3.32
Total of year	25.39	19.21	29.16	31.91	20.30	45.61	50.10	70.79	30.64	37.82

FREQUENCY OF RAINY DAYS IN AUSTRALASIA.

Month.	Adelaide.	Port Phillip.	Hobart Town.	Sydney, W.S.J.	Sydney, City.	Port Macquarie.	New Plymouth, N.Z.	Wellington, N.Z.	London.
January	4	6	8	10	13	11	6	8	15
February	4	5	6	11	12	11	8	8	15
March	5	7	5	12	13	12	7	7	14
April	10	11	5	13	12	12	12	9	15
May	10	13	9	12	12	11	14	14	15
June	11	11	10	11	12	9	16	17	12
July	14	12	13	10	13	9	13	16	14
August	15	14	8	7	11	8	15	14	15
September	11	12	9	9	11	9	15	13	14
October	10	12	13	12	12	10	13	12	15
November	6	10	12	10	11	9	11	13	15
December	5	7	11	12	11	9	10	10	16
Total	125	120	109	129	143	120	140	141	175

The number of days on which an inch of rain or more fell in Sydney during three years are altogether 30, being thus distributed:—

January	2	May	7	September	1
February	2	June	2	October	1
March	2	July	4	November	3
April	3	August	2	December	1

The following is an analysis of the measurement of rain during the same years, shewing the number of days in which showers of rain of each intensity fell, with corresponding numbers for the climate of London derived from Mr. Howard's observations during the three years 1827-9.

Depth of rain in one day. Inches.	Number of days.		Depth of rain. Inches.	Number of days.		Depth of rain. Inches.	Number of days.	
	Sydney.	London.		Sydney.	London.		Sydney.	London.
			.9 to 1.0	8	3			
.0 .0	708	746	1.0 — 1.1	6	1	2.3 to 2.4	1	...
.0 to .1	153	128	1.1 — 1.2	2	2	2.5 — 2.6	1	...
.1 — .2	77	72	1.2 — 1.3	4	...	2.9 — 3.0	1	...
.2 — .3	37	55	1.3 — 1.4	1	1	3.2 — 3.3	2	...
.3 — .4	25	36	1.4 — 1.5	2	...	3.4 — 3.5	1	...
.4 — .5	16	25	1.5 — 1.6	3	...	3.5 — 3.6	1	...
.5 — .6	14	11	1.6 — 1.7	1	..	6.0 — 6.1	1	...
.6 — .7	13	3	1.7 — 1.8	2	...			
.7 — .8	5	6	1.9 — 2.0	1	...			
.8 — .9	8	7	2.1 — 2.2	1	...			

It would seem that during the years of which the results are taken, rainy days were more frequent in Sydney than in London. But allowing for this, it may be roughly stated that in Sydney the showers of rain are as follows:—

15 per cent. falls in showers of between .0 and .2 inch.
25 ,, ,, ...2 ,, .5 ,,
20 ,, ,, ...5 ,, 1.0 ,,
20 ,, ,, ... 1.0 ,, 2.0 ,,
20 ,, ,, ...more than 2.0 ,,

Whereas we find that in London

"20	per cent.	falls in showers of	between	.0	and .2	inch.
55	,,	,, ...		.2	,, .5	,,
20	,,	,, ...		.5	,, 1.0	,,
5	,,	,, ...	more than	1.0		,,

"The difference between these is very striking: while moderate showers of less than half an inch supply 75 per cent. of the total quantity of rain in London, we here receive only 40 per cent. in this manner. In Sydney 60 per cent. of the rain may be said to fall in torrents of between half an inch and perhaps 10 inches deep; the quantity of two inches per day is rarely known to occur in London, and only 25 per cent. falls at a heavier rate than half an inch per day."

Mr Jevons gives the following details of the heaviest falls of rain in Sydney:—

"1855, March 24th to April 5th, total, 22.12 inches.

"During 24 hours preceding 9 a.m. of April 2nd, 8.056 inches were collected in my gauge, which being, however, badly placed, I may state that Professor Smith measured at the Sydney University, from March 29th to April 6th, 23.12 inches, and during one hour of this period fully two inches fell.

"1855, May 2nd to 7th, total, 6.68 inches.
1855, September 15th to 17th, total, 4.50 inches.
1856, October 30th to November 7th, total, 11.28 inches.
1856, December 28th to January 1st, 1857, total, 3.31 inches.
1857, June 16th to 19th, total, 4.46 inches.
1857, July 26th to 30th, total, 5.18 inches.
1857, August 20th to 23rd, total, 3.59 inches.
1858, May 25th, 8 p.m. to 26th 4 p.m., total, 6.10 inches, in 20 hours.

"Out of 156 weeks, from July, 1855, to June 1858, there were 42 during which more than one inch of rain fell. Out of every four weeks, the rains may be considered excessive during one week at least. The total rain of the 156 weeks amounts to 136.82 inches; that of the 42 weeks of excessive rain to 101.50 inches. The difference, viz., 35.32 or about 12 inches per annum, represents the occasional light and beneficial rains. Again, even allowing what is by no means evident, that during a week of excessive rain, the first inch is always beneficial, we must subtract 42 inches from 101.50 and the remainder, 59.50 or about 20 inches per annum, is a rough measure of the quantity of water which passes away in floods."

In addition to the above, the following instances of excessive rains are recorded in old journals.

1820, December 4th—Exceedingly heavy rains are described as occurring this day with the wind from south to S.E. Immense quantities of stones were washed off the "Rocks."

1834, March 30th—During four hours of this day, the torrents of rain which fell in Sydney without intermission exceeded anything of the sort known before. Pitt Street was like a swollen river, one lad being carried away in the water and nearly drowned. Drains were burst and ravines cut in the streets. The foundations of a great many houses were greatly injured, and some fell in; £10,000 would not cover the damage done to the town by four hours' rain.

1841, April 20th—Most violent storms of rain. Rain fallen on that day and night amounting to 20.12 inches. Wind E.N.E. to S.S.E., without squalls.

1844, Oct. 15th—Furious gale and fearful deluging rains up to noon of 16th; during 22 hours there fell 20.41 inches of rain, thus:—

	P.M.	INCHES.	DIRECTION OF WIND.
Oct. 15th, 1844.	3. 0	3.48	S.S.E. to South
,,	5. 0	5.40	South to S.W. by S.
,,	6.30	1.36	S.W. by S. to S.W.
,,	8. 0	1.53	S.W., S.W. by W.
,,	10.30	2.68	S.W. by S., S. by W.
16th, a.m.	7. 0	5.96	S.W. by S., S. by W.

The following table is given by Mr. Jevons; it is liable to the remark that it exhibits rather a specimen of the coast climate in these latitudes, than affording any idea of that of the interior.

ANNUAL VARIATION OF THE RAINFALL IN AUSTRALIA.

Year.	Sydney.	Port Macquarie.	Hobart Town.	Port Phillip.
1841	76.31	52.49	13.95	30.18
1842	48.32	71.76	23.60	41.16
1843	62.78	68.39	13.43	21.54
1844	70.67	72.02	26.25	28.26
1845	62.01	44.57	16.68	23.93
1846	43.84	41.48	21.96	30.53
1847	72.79	50.05	14.46	23.99
1848	59.16	113.82	23.62	33.15
1849	21.48	47.03	33.52	44.25
1850	44.88	81.03	14.51	26.98
1851	35.13	92.02	17.98	.....
1852	43.78	109.32	23.62	.....
1853	46.10	.....	14.53	.....
1854	29.28	.....	30.56	.....
1855	52.85	.....	18.25	.....
1856	43.30	.....	22.73	.....
1857	50.95	.....	17.14	.....
Mean.	49.00	70.79	20.40	29.16

RAINFALL IN TASMANIA AND SOUTH AUSTRALIA.

Taken at various places during the Years 1857, 1858, 1859, and 1860.

	Year.	Jan.	Feb.	Mar.	Apr.	May.	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Hobart Town Tasmania.	1858	6.43	4.42	2.38	0.44	4.14	1.12	1.75	10.16	1.47	0.75	4.03	1.98	33.07
	1859	4.61	1.70	0.26	1.43	1.47	3.80	2.09	1.70	1.39	1.91	1.70	1.25	23.31
	1860	2.22	2.33	1.68	2.86	1.70	1.30	0.48	1.11	1.25	3.09	2.76	2.27	21.05
Port Augusta	1860		2.86		0.84	1.17	0.68	0.34	0.33	0.47	1.61	0.55	1.11	9.96
Bungaree ...	1860	0.00	0.00	2.37	2.54	2.12	3.09	0.70	0.83	2.10	2.61	0.50	1.03	18.89
Kooringa ...	1859	2.79	0.07	0.04	0.24	2.50	0.66	0.24	0.81	0.58	1.21	0.29	0.32	9.75
	1860	0.06	0.21	2.72	2.01	1.30	1.51	0.38	1.16	2.16	1.57	0.46	0.44	13.98
Adelaide	1857	0.30	0.64	3.75	0.77	0.69	3.90	1.15	3.09	1.04	2.05	1.63	1.14	20.15
	1858	1.10	3.10	0.21	1.71	2.72	1.29	2.82	1.53	1.98	0.60	1.82	1.37	20.25
	1859	0.17	1.05	0.00	0.97	4.81	1.95	0.77	2.56	0.74	1.25	0.52	0.41	15.20
	1860	0.12	0.00	2.07	3.99	1.99	3.42	1.28	0.66	1.66	1.45	0.89	0.60	18.13
Mount Lofty	1858	0.00	0.00	0.62	2.45	6.21	3.35	9.73	4.34	6.10	1.35	0.49	5.00	39.64
	1859	0.71	2.47	0.06	1.60	8.13	4.16	4.48	2.64	3.37	2.28	1.25	0.92	32.00
	1860	0.48	0.05	2.16	5.67	4.07	6.34	2.67	1.43	3.84	3.61	1.67	2.11	34.10
O'Halloran Hill	1860	0.30	0.03	3.40	7.14	3.81	4.25	1.42	0.84	1.89	1.84	0.75	0.57	24.24

INTENSITY OF RAINFALL IN EUROPE.

This is given to some extent in the description of floods, pages 137 to 148; in several of the rivers will also be found records of excessive rains and their effects. The heaviest falls of rain in this country and in France are decidedly from thunder storms, as likewise in South Africa. The heaviest within our own knowledge, fell in Westminster, Lambeth, and Vauxhall, on the 1st of August, 1846, to the amount of 4 inches in three hours; during half an hour of the time the fall was composed of hail; and in less than one hour flat hollow roads were 2 feet deep in water—for neither side drains nor gullies were competent to carry off one-tenth of the water that fell. Another memorable storm, of a similar character, occurred on the 13th of August, 1857, which caused an accident by carrying away the permanent way of the Great Northern Railway, on a brook at Carlton, near Newark. Mr. Lowe observed the storm at Nottingham, 20 miles west of the accident; he says that there were three distinct thunder storms; between 1 and 2.30 p.m. 1¼ inch of rain fell; 7.15 to 9.30 p.m. 1¼ inch fell; 9 to 10 p.m. 3¼ inches fell; so that the total fall was 5¾ inches. This storm must have traversed a very considerable area, and was probably of circular or crescent form; for at Retford, 12 miles north of the accident, the rain was 2 inches between noon and 6 p.m., and 2 inches more in the four hours between 7 and 11 p.m.; the total rain between noon and midnight being 4.10 inches. The observer, Mr. S. Piercy, considered the storm to be 10 to 11 miles in width, passing from N.W. to S.E.

The greatest fall in one day is given in the tables, for several important places, especially in the Lake district; similar information will be found in juxta-position with the greatest and average evaporation and mean temperature for several climates, pages 332-5.

In the Report on supply of water to Manchester, by S. C. Homersham, Esq., C.E., he makes a total of falls of .4 inch and upwards in each twenty-four hours, from observations between Manchester and Sheffield, by which it appears that they are from 40 to 50 per cent. of the total rain. He records the following facts:—"At Waterhouse Lock on the Macclesfield Canal, on the night of the 8th May, 1847, a depth of two inches of rain fell during twelve hours; and, in the same time, 1.8 inches fell at Coomb's reservoir. Dr. Dalton remarks, that on the 22nd April, 1792, at Kendal, 4.592 inches of rain fell in twenty-four hours. It is not an uncommon circumstance for .3 inch of rain to fall in hilly districts, in one hour; this quantity was registered at Coomb's reservoir on the 5th April, 1847. In 1844, out of 33 inches which fell at Chapel-en-le-Frith, one half was registered in the short space of thirty-days."

At Little Bridy on September 29, 1855, there was a fall of .68 of rain in four-and-a-half minutes. At Huntsham Court, near Bampton, Devon, 3.87 inches fell between 3 and 7 p.m. on the 1st of July, 1857.

We have endeavoured to shew what may be expected in this climate during a very wet year (1852) by a table of the greatest fall in twenty-four hours, and also in a very short space of time, at various places, collated by Mr. Glaisher, from observations by members of the British Meteorological Society. This table is at pages 310-11, with that of the "Distribution of Rain at Greenwich," wherein all the falls of rain above half-an-inch in depth, between 1837 and 1858, are extracted from the records at the Royal Observatory. Maximum falls of rain are also given for Dublin, Limerick, and the lake district, at pages 318 and 324.

Further notes on the subject of heavy rains and their effects, will be found in Division II., at pages 158-9, 161, 172-4, and at other parts of this treatise.

ON EVAPORATION.

It is an extremely difficult matter (even if possible) to arrive at a correct knowledge, from the indications of a hygrometer, of the amount of evaporation at any moment from a surface of water or land; so many disturbing elements enter into the question. For instance, the temperature of the evaporating surface, the degree of moisture of that surface, the force of the wind and the aspect of the sky, all contribute to the result.

It has been noticed by M. Aimé Drian that when the temperature of the dew point is higher than that of the evaporating surface, water is deposited on that surface; this he styles *negative evaporation*. (See "Annuaire de la Société Météorologique de France," 1853). This disturbing element principally affects bad conductors of heat, those whose specific heat is large, and above all others a reservoir or lake of water when its temperature is below 40° Fahrenheit. Observations shew that near London the evaporation from the surface of water in a reservoir is nearly equal in a year to the rainfall of the district.

From land the amount of evaporation must generally be below the actual rainfall, but it will differ according to the character of the soil, its vegetation, the contour of the district, and the character of the rainfall during any particular season. After rain, evaporation proceeds rapidly from a light soil, where the vegetation is scant and the surface exposed to the full action of the sun and wind; the surface soon becomes desiccated, and the amount of evaporation falls off. In a well-wooded district, although evaporation from the surface is less active, yet the rain which percolates the soil is arrested by the spongioles at the extremity of the roots of every plant, passes upwards by the process of endosmose, and is finally returned to the atmosphere from the surfaces of the leaves. This source of evaporation is much more constant than in the preceding instance, and is especially active in the spring and early summer months, during the period of foliation.

In the autumnal months the heated earth and water throw vapour into the atmosphere, having a tension greater than that which the temperature of the air can sustain; it condenses in fog, which deposits on every leaf and blade of grass, lading them with dew drops: this is termed vaporization by physicists.

The term evaporation has a double signification; the engineer regards it as much with reference to the quantity lost when the soil is wetted by rain or dew, as the mere amount daily evaporated from exposed surface of water, which is that called evaporation by the meteorologist.

So far as the first named kind of loss by evaporation is concerned, we fear it is hazardous to pronounce that really precise philosophically correct observations can be made; we will therefore refer to the various Dalton gauge experiments recorded in the second Division of this Treatise, pages 121-6, 148, &c. The comparative tables of observed rainfall and of actual flow from large districts also throw considerable light on the loss which obtains from evaporation and vegetable absorption.

In using the term *evaporation*, as applied to this great process which is always at work in nature, the engineer has only to deal with the resultant facts; it is quite clear that the amount actually passing off the ground in the state of vapour may even exceed that shewn by the rain-gauge, if moisture be artificially supplied. As an instance, we have drawn up the following statement of evaporation from a surface of water in a shallow vessel, as compared with the amount of rain received in an

adjacent gauge. The observations were made by Mr. Luke Howard, at Plaistow, and are averaged from 1812 to 1815 :—

	Jan. Ins.	Feb. Ins.	Mar. Ins.	Apr. Ins.	May. Ins.	June. Ins.	July. Ins.	Aug. Ins.	Sept. Ins.	Oct. Ins.	Nov. Ins.	Dec. Ins.
RAIN.....	1.93	2.00	1.46	2.48	1.71	2.14	2.19	0.98	2.85	2.05	1.75	1.60
EVAP.....	1.20	1.63	1.42	2.47	2.67	2.85	2.99	2.25	1.33	.49	.44	.39

	AVERAGE RAIN. inches.	EVAP. inches.
Adopting the four months' mode of division, we have for the WINTER PERIOD	7.28	3.66
,, SPRING ,, ...	7.79	10.41
,, SUMMER ,, ...	8.08	7.06
Total average for the Years being.....	23.15	21.13

From Daniel's experiments near London, the proportion of evaporation, taking the whole year as 1.00, is for November to February .104, March to June .434, July to October .462.

Vallé's experiments at Dijon on evaporation from a dish of four square mètres area, gave the following results :—

	1846	1847	1848	1849	1850	1851	1852	Mean.
Rainfall in inches	29.7	27.1	26.6	23.3	25.1	24.5	32.0	26.9
Evaporation ,,	26.7	26.4	25.1	26.4	32.0	20.7	25.6	26.1

He also compared the evaporation from a dish of thirty square mètres area, which gave 29.16 inches of evaporation for 1851, against 20.7 inches from the larger vessel.

Howard's experiments at Tottenham for three years, gave 37.85 inches per annum when the gauge was 43 feet above the ground; 33.37 inches when lower and less exposed; and 20.28 inches when the dish was placed on the ground.

The experiments of Bishop Watson on evaporation went to shew that, during the time of bright hot sun, when there had been no rain for a month, the evaporation from grass was at the rate of ·035 inch in 12 hrs. In another experiment, after a thunder-storm there was .087 ,, ,,

The author of the article *Physical Geography*, in the publication of the Society for Promoting Useful Knowledge, has the following remarks upon this subject:

"Other things being equal, evaporation is the more abundant, the greater the warmth of the air *above* that of the evaporating body, and least of all when their temperature is the same. Neither does much take place whenever the atmosphere is more than fifteen degrees colder than the surface upon which it acts. Winds powerfully promote evaporation, because they bring the air into continual, as well as into closer and more violent contact with the surface acted upon; and also, in the case of liquids, increase, by the agitation which they occasion, the number of points of contact between the atmosphere and the liquid.

"In the temperate zone, with a mean temperature of 52½ degrees, the annual evaporation has been found to be between 36 and 37 inches. At Cumana, on the coast of South America (N. lat. 10½), with a mean temperature of 81.86 degrees, it was ascertained to be more than 100 inches in the course of the year; at Guadaloupe, in the West Indies, it has been observed to amount to 97 inches. The degree of evaporation very much depends upon the difference between the quantity of vapour which the surrounding air is able to contain *when saturated*, and the quantity which it actually contains. M. Humboldt found that in the torrid zone, the quantity of vapour contained in the air is much

nearer to the point of saturation than in the temperate zone. The evaporation within the tropics, and in hot weather in temperate zones, is on this account less than might have been supposed from the increase of the temperature.

COMPARATIVE RAINFALL AND EVAPORATION.

In order to shew the relative amounts of rain and evaporation with the concurrent temperatures, we have placed these phenomena in tables, selected from trustworthy observations: these will be found at pages 325 and 332 to 335.

The Little Bridy table has been prepared from his observations by H. S. Eaton, M.A., a zealous follower of this branch of natural science; the Oxford table is from the official publications of the late Manuel Johnson, M.A., Ratcliffe observer. The tables of tropical rainfall and evaporation are prepared from the observatory returns.

We have had the pleasure of receiving from Mr. A. Golding, State engineer at Copenhagen, a paper on rainfall and evaporation at that place; his results are embodied in the pages 296*c*, and 296*d*. The first table gives the detail of monthly rainfall for various places in Denmark (see also page 359.) and of five stations, all within four miles of Copenhagen. There is some difference in the fall, which the writer attributes to Vaudlose and Vangede being about three times as far from the sea as Emdrup and Peblinge. The second table gives the results of careful experiments on evaporation from water, and also of experiments on the quantity of water evaporated from a saturated plot of long grass in a vessel which had no outlet, and from a similar plot on which the grass was kept short.

The following table of mean temperatures will be useful for indicating the depth and quality of springs, and in reference to evaporation.

MEAN TEMPERATURE IN DIFFERENT LATITUDES.

Stations.	Lat. N.	Temp.	Stations.	Lat. N.	Temp.
	D. M.	Fah.		D. M.	Fah.
Equator	0. 0	81. 50	Milan	45. 28	58. 28
Columbo	6. 58	80. 90	Nantes	47. 13	55. 35
Chandernagore	22. 52	75. 10	Paris	48. 50	53. 65
Cairo	30. 02	70. 56	Brussels	50. 50	51. 47
Funchal	32. 37	68. 62	London	51. 30	50. 74
York, W. A., S. Lat.	31. 53	65. 3	Dublin	53. 21	48. 65
Sydney ,,	33. 51	61. 3	Kendal	54 17	47. 58
Auckland ,,	36. 57	57. 1	New Malton	54. 10	47. 53
Port Phillip ,,	38. 18	57. 6	Copenhagen	55. 41	45. 95
New Plymouth ,,	39. 4	56. 8	Edinburgh	55. 57	45. 64
Wellington ,,	41. 17	57. 9	Carlscrona	56. 16	45. 46
Lanceston ,,	41. 30	53. 2	Stockholm	59. 20	41. 57
Hobart Town ,,	42. 53	53. 3	Upsal	59. 51	40. 94
Rome	41. 54	60. 66	Abo	60. 27	40. 28
Montpelier	43. 36	59, 03	Umeo	63. 50	35. 96
Bourdeaux	44. 50	57. 82	Uleo	65. 30	34. 38

WATER SUPPLY AND DRAINAGE AREAS.

The table at page 297 is given as a guide to the relative requirements of water for artificial distribution: it is not adapted to any theory of demand or supply, but merely to shew what the results based on given data will afford; each case must stand on its own merits.

DENMARK.

RAINFALL AND EVAPORATION.

The first four Stations are in various parts of Denmark; the remaining Stations are all within four miles radius from Copenhagen.

N. Lat. 55.41; E. Long. 12.34.

		Jan.	Feb.	Mar.	Apr.	May.	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Altona	1854	1.3	0.5	1.5	1.2	0.9	0.9	4.5	0.7	1.5	0.6	0.4	2.4	16.4
Neumunsle	,,	2.0	0.7	2.3	1.6	0.6	1.7	4.0	0.5	1.7	1.3	0.6	1.4	18.4
Neustadt	,,	1.5	0.4	1.2	2.3	0.9	0.9	2.1	0.6	0.4	0.9	1.0	1.1	13.4
Sylt	,,	0.4	0.6	1.0	1.5	0.2	0.1	1.1	2.3	5.1	2.2	0.6	1.0	16.1
Botanic Gardens, 10 feet above the Sea.	1846	2.3	2.2	3.3	1.5	0.9	1.1	2.9	0.9	0.5	1.3	1.0	1.4	19.3
	1847	1.3	1.5	1.5	1.7	2.4	2.0	1.5	1.0	2.6	1.4	0.9	0.7	18.5
	1848	0.4	2.2	1.5	2.5	0.4	3.8	1.5	4.3	1.4	4.1	2.5	0.7	25.3
	1849	2.1	1.7	1.4	0.7	0.4	4.1	4.8	1.8	1.9	3.7	1.0	1.4	25.0
	1850	0.7	2.1	0.4	2.1	1.5	1.4	4.6	2.4	2.3	2.1	3.1	0.8	23.5
	1851	1.2	1.2	2.5	3.5	1.9	2.7	1.8	1.1	1.0	1.8	3.4	0.5	22.6
	Mean	1.3	1.8	1.8	2.0	1.2	2.5	2.9	1.9	1.6	2.4	2.0	0.9	22.3
No. of Days		18	16	12	13	7	10	10	9	9	15	16	12	14.7
Peblinge Lake. 20 feet above the Sea.	1848	0.5	2.6	1.4	2.4	0.4	4.2	1.7	5.1	1.7	5.4	3.1	1.0	29.5
	1849	2.7	2.2	2.4	0.7	0.5	4.1	4.4	2.4	1.4	4.3	1.1	1.7	27.9
	1850	1.1	3.6	0.4	2.0	1.6	1.4	4.1	2.3	2.2	2.6	3.9	0.7	25.9
	1851	1.5	1.7	2.7	3.8	1.7	3.0	1.4	1.3	1.2	2.2	4.0	0.7	25.2
	1852	3.1	2.4	0.6	0.7	2.5	3.1	0.2	1.6	3.6	3.8	4.9	4.2	30.7
	1853	2.6	0.9	0.5	2.0	1.5	0.8	2.0	1.6	1.6	1.2	0.6	0.1	15.4
	1854	1.1	1.2	0.5	1.0	1.6	2.0	1.1	5.3	2.7	1.4	1.1	3.1	22.1
	1855	0.9	0.3	1.0	1.5	2.2	2.1	2.7	2.8	1.0	2.8	0.1	1.1	18.5
	1856	1.7	1.5	0.1	2.5	1.7	2.1	2.5	1.3	2.3	0.9	2.6	2.5	21.7
	1857	1.0	1.0	1.1	2.1	0.4	0.5	1.5	1.5	1.2	1.3	1.0	0.6	13.2
	1858	1.0	0.6	0.5	0.6	3.3	1.3	2.8	1.9	0.6	1.1	0.9	0.7	15.3
	1859	0.9	2.0	1.4	1.8	0.5	2.2	1.5	1.7	4.6	1.2	2.4	1.2	21.4
	Mean	1.5	1.6	1.0	1.8	1.5	2.2	2.2	2.4	2.0	2.4	2.1	1.5	22.2
Emdrup, 50 feet above the Sea.	1848	0.4	2.5	1.2	2.2	0.4	3.6	1.5	5.0	1.6	4.9	3.0	1.0	27.3
	1849	2.9	1.5	1.2	0.9	0.5	4.3	4.0	2.6	2.3	4.3	1.2	1.7	27.4
	1850	0.9	6.3	0.3	2.1	1.6	1.8	4.8	2.3	1.7	2.7	3.6	0.7	28.8
	1851	1.0	0.9	2.2	3.3	2.0	3.0	1.2	1.2	1.0	2.0	3.7	0.6	22.1
	1852	2.5	2.3	0.6	0.6	2.4	2.7	0.4	1.7	3.5	2.8	4.6	3.8	27.8
	1853	1.7	0.7	1.4	2.1	1.6	1.1	3.2	2.0	2.1	1.6	0.5	0.3	18.3
	1854	1.0	1.2	0.6	0.7	1.6	2.1	1.5	4.4	2.7	1.5	0.7	2.5	20.6
	1855	0.6	0.1	1.2	1.6	1.8	2.0	2.6	3.0	0.6	2.5	0.1	1.5	17.6
	1856	2.2	1.5	0.2	2.0	1.8	2.1	2.9	1.6	2.6	0.7	1.7	2.3	21.6
	1857	2.0	0.7	1.0	1.6	0.5	0.9	1.6	1.9	1.2	1.6	0.7	0.9	14.6
	1858	1.5	0.2	1.0	0.5	3.4	1.1	3.1	1.5	0.9	1.4	0.5	1.2	16.3
	1859	1.1	2.1	1.4	1.6	0.6	2.1	1.6	1.6	4.1	1.8	1.6	1.3	21.0
	Mean	1.5	1.7	1.0	1.6	1.5	2.2	2.4	2.4	2.0	2.3	1.8	1.5	21.9
Mean monthly rainfall of 12 years:—														
Botanic Gardns	10 feet	1.5	1.5	1.1	1.8	1.5	2.2	2.2	2.4	2.0	2.2	2.0	1.5	21.9
Peblinge Lake	20 ,,	1.5	1.6	1.0	1.8	1.5	2.2	2.2	2.4	2.0	2.4	2.1	1.5	22.2
Emdrup	50 ,,	1.5	1.7	1.0	1.6	1.5	2.2	2.4	2.4	2.0	2.3	1.8	1.5	21.9
Vaudlose.....	30 ,,	1.6	2.0	1.2	1.9	1.6	2.2	2.6	2.5	2.1	2.6	2.2	1.6	24.1
Vangede	90 ,,	1.6	1.5	1.0	1.6	1.5	2.2	2.3	2.4	2.1	2.2	1.7	1.5	21.6

DENMARK.

RAINFALL AND EVAPORATION.

The evaporation from long and short grass is taken by maintaining saturation in a closed vessel, and taking the quantity required for the full supply.

N. Lat. 55.41 ; E. Long. 12.34.

		Jan.	Feb.	Mar.	Apr.	May.	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Emdrup, Evaporation from Water.	1849	1.1	0.3	1.8	2.5	4.1	5.8	4.7	4.0	2.6	1.1	0.9	0.6	29.5
	1850	1.1	0.3	1.2	1.7	4.5	5.6	4.8	4.8	2.4	1.6	0.9	0.2	29.1
	1851	0.5	0.4	0.7	1.7	4.2	4.8	5.7	5.1	2.7	1.5	0.6	0.5	28.4
	1852	0.7	0.5	0.8	2.4	3.8	4.6	6.4	4.5	2.7	1.7	0.8	0.5	29.4
	1853	0.5	0.1	0.7	1.0	4.1	6.2	5.1	4.2	2.8	1.1	0.6	0.5	26.9
	1854	0.5	0.9	0.9	3.2	3.3	4.5	5.2	4.3	2.6	1.2	0.7	0.6	27.9
	1855	1.0	1.1	0.5	1.2	2.6	4.1	4.7	4.1	2.8	1.4	0.9	0.7	25.1
	1856	0.5	0.5	1.2	2.1	2.8	4.6	4.3	4.0	2.0	0.9	0.6	0.5	24.0
	1857	0.7	0.6	0.6	1.4	4.1	6.6	5.9	4.3	3.2	1.4	0.7	0.4	29.9
	1858	0.4	0.7	1.2	3.1	3.1	6.1	4.9	5.6	2.8	1.6	0.7	0.4	30.6
	1859	0.3	0.5	0.7	1.9	4.3	5.8	5.3	3.8	1.8	1.0	0.7	0.3	26.4
	Mean	0.7	0.5	0.9	2.0	3.7	5.4	5.2	4.4	2.6	1.3	0.7	0.5	27.9
Evaporation from Short Grass.	1852	1.0	1.1	1.4	2.2	4.1	4.7	6.7	4.7	3.0	1.9	1.0	0.8	32.6
	1853	0.8	0.1	0.8	1.6	5.1	6.0	5.0	4.3	3.1	1.2	0.7	0.5	29.2
	1854	0.5	1.1	1.7	4.3	4.2	4.8	5.3	4.9	2.9	1.4	0.7	0.6	32.4
	1855	1.1	1.0	0.8	2.1	3.4	4.5	4.7	4.2	2.9	1.1	0.7	0.2	26.7
	1856	0.5	0.5	1.6	2.6	3.3	5.3	3.8	4.1	2.0	1.0	0.5	0.5	25.7
	1857	0.7	0.8	0.7	1.4	4.8	6.7	6.1	5.5	3.2	1.2	0.7	0.4	32.2
	1858	0.5	0.7	1.3	3.4	3.6	5.5	4.8	5.9	3.4	1.9	0.7	0.5	32.2
	1859	0.2	0.7	1.4	2.9	4.6	6.3	5.5	3.9	1.8	1.0	0.8	0.7	29.8
	Mean	0.7	0.8	1.2	2.6	4.1	5.5	5.2	4.7	2.8	1.3	0.7	0.5	30.1
Evaporation from Long Grass.	1849	1.1	0.4	1.8	2.5	4.5	5.7	5.2	4.4	3.0	1.6	1.3	0.6	32.1
	1850	1.3	0.4	1.6	2.2	4.9	5.9	5.5	5.8	3.0	2.5	1.2	0.3	34.6
	1851	1.1	0.7	1.3	2.8	6.0	9.0	18.5	12.5	7.1	4.3	2.0	0.6	65.9
	1852	1.0	1.1	1.5	3.2	5.7	8.5	14.0	10.3	6.4	4.4	1.6	0.9	58.2
	1853	0.8	0.1	0.8	1.6	5.4	7.6	10.3	10.8	8.2	4.0	1.7	0.6	51.9
	1854	0.5	1.1	1.7	4.2	4.6	6.4	9.1	9.5	7.2	3.5	1.1	0.6	49.5
	1855	1.1	1.0	0.8	2.1	3.4	4.9	5.2	5.2	3.4	2.1	1.1	0.3	30.6
	1856	0.5	0.5	1.6	2.6	3.3	5.5	4.8	5.1	3.0	1.1	0.7	0.5	29.2
	Mean	0.9	0.6	1.4	2.6	4.7	6.7	9.3	7.9	5.2	2.9	1.3	0.5	44.0

Mean Annual Rainfall and Evaporation in the Copenhagen District.

Rainfall.	1848	1849	1850	1851	1852	1853	1854	1855	1856	1857	1858	1859	Mean.
Botanic Gardens	25.2	24.9	23.6	22.6	26.8	19.3	23.0	20.6	22.6	14.1	15.8	23.7	21.9
Peblinge Lake	29.5	27.9	25.9	25.2	30.7	15.4	22.1	18.5	21.7	13.2	15.3	21.4	22.2
Emdrup	27.3	27.4	28.8	22.0	27.8	18.3	20.6	17.7	21.6	14.6	16.3	21.1	21.9
Vandlose	31.6	30.3	29.0	25.9	32.7	21.0	22.3	21.1	23.5	15.7	16.9	23.7	24.5
Vangede	30.2	30.9	32.4	26.0	33.2	17.4	19.4	18.8	22.9	16.0	17.3	23.5	24.1
Evaporation.													
Water	...	29.5	29.1	28.4	29.4	26.9	27.9	25.1	24.0	29.9	30.6	26.4	27.9
Short Grass	...	...	...	...	32.6	29.1	32.4	26.7	25.7	32.2	32.2	29.8	30.1
Long Grass	...	32.1	34.6	65.9	58.2	51.9	49.5	30.6	29.2	...	...	...	44.0

WATER SUPPLY AND DRAINAGE AREAS

Required for various amounts of Population, at different rates of Supply, with a Guide to the Cubic Contents of Reservoirs, where that method of Supply is adopted.

Discharge required.		Number of Population.			Gathering Ground required.		Reservoir required.
Cubic Feet per Minute.	Gallons per Diem.	At 30 Gallons per Head, per Diem.	At 40 Gallons per Head, per Diem.	At 50 Gallons per Head, per Diem.	With Stream delivering 8 cubic feet per sq. mile.	With 12 in. of Rain per ann. or 53 c. feet per minute, per sq. mile.	Holding Water for 4 months, at 53 c. feet per min.
Cubic Feet.	Millions.	Number.	Number.	Number.	Square Miles.	Square Miles.	Cubic Feet. Millions.
27.8	.25	8,333	6,250	5,000	3.48	.52	4.88
55.7	.50	16,666	12,500	10,000	6.96	1.05	9.76
83.5	.75	25,000	18,750	15,000	10.44	1.57	14.65
111.4	1.00	33,333	25,000	20,000	13.93	2.10	19.53
139.2	1.25	41,666	31,250	25,000	17.41	2.63	24.42
167.1	1.50	50,000	37,500	30,000	20.89	3.15	29.30
195.0	**1.75**	**58,333**	**43,750**	**35,000**	**24.37**	**3.68**	**34.18**
222.8	2.00	66,666	50,000	40,000	27.85	4.21	39.07
250.7	2.25	75,000	56,250	45,000	31.33	4.73	43.95
278.5	2.50	83,333	62,500	50,000	34.82	5.26	48.84
334.3	3.00	100,000	75,000	60,000	41.78	6.31	58.60
390.0	3.50	116,666	87,500	70,000	48.75	7.36	68.37
445.7	4.00	133,333	100,000	80,000	55.71	8.41	78.14
557.1	**5.00**	**166,666**	**125,000**	**100,000**	**69.64**	**10.52**	**97.68**
668.6	6.00	200,000	150,000	120,000	83.57	12.62	117.21
780.0	7.00	233,333	175,000	140,000	97.50	14.74	136.75
891.4	8.00	266,666	200,000	160,000	111.43	16.82	156.28
1,002.8	9.00	300,000	225,000	180,000	123.11	18.92	175.82
1,114.3	10.00	333,333	250,000	200,000	139.29	21.02	195.36
2,228.6	20.00	666,666	500,000	400,000	278.58	42.05	390.72
3,343.0	**30.00**	**1,000,000**	**750,000**	**600,000**	**417.87**	**63.07**	**586.08**
4,457.3	40.00	1,333,333	1,000,000	800,000	557.16	84.10	781.44
5,571.6	50.00	1,666,666	1,250,000	1,000,000	696.45	105.13	976.80
6,686.0	60.00	2,000,000	1,500,000	1,200,000	835.74	126.15	1,171.16
7,800.3	70.00	2,333,333	1,750,000	1,400,000	975.04	147.18	1,367.52
8,914.6	80.00	2,666,666	2,000,000	1,600,000	1,114.33	168.21	1,562.88
10,029.0	90.00	3,000,000	2,250,000	1,800,000	1,253.62	189.23	1,758.24
11,143.3	**100.00**	**3,333,333**	**2,500,000**	**2,000,000**	**1,392.91**	**210.25**	**1,953.60**

	Height above Sea.	Year commencing Observation.	Years of Observation.	Winter	Spr
	Feet.	A.D.	Number	Ins.	In
Penzance .....Cornwall ..	40	1825	9	17.4	12
St. Breock..... „ ..		1837	13		
Pencarrow..... „ ..		1841	3		
Plymouth ..... . Devon ..	30	1826	10	14.2	9
Goodamoor ..... „ ..	600	1834	16	23.0	14
Honiton ..... „ ..		1841	5	11.3	9
Exeter ..... „ ..	141	1825	25	11.0	8
Bath ..... Somerset ..		1841	3		
Hungerford ..... Berks ..	320	1838	12		
Reading..... „ ..		1832	17	8.2	7
Gosport ..... Hampshire ..	30	1825	7	10.6	8
Hastings .....Sussex..		1838	12		
Chiswick	25	1825	25	7.4	6
Cobham Lodge .....Surrey..	80	1825	25	7.7	6
Greenwich Observatory	143	1838	12		
London (Howard's average)		1800	20	8.9	6
Tottenham.....Middlesex..	50	1812	7	8.5	7
Epping ....Essex..		1825	10	8.1	7
Aylesbury .....Buckingham..		1847	3		
Wellingborough.. Northampton	160	1830	20	7.7	7
Swaffham Balbeck..Cambridge..		1841	7	6.4	7
Dickleborough .....Norfolk..	120	1840	10		
Felthorp ..... „ ..		1843	5		
Boston .....Lincoln..	30	1825	25	6.5	7
Nottingham (Highfield House) ..		1844	6	7.2	8
Chapel-en-le-Frith.....Derby..	1121	1840	8		
Hyde.....Lancashire..	320	1831	10	11.8	9
Liverpool..... „ ..		1826	23		
Manchester ..... „ ..		1813	22	12.2	10
Fairfield ..... „ ..	320	1840	8		
Bolton ..... „ ..	320	1831	10	17.7	12
Bury..... „ ..	300	1832	13		
Sowerby Bridge .....York..	300	1830	11	9.9	7
Stubbins.. ..... „ ..		1830	11		
Moss Lock, near Rochdale	500	1830	11	10.9	7
Rochdale	500	1832	16		
White Holme, Blackstone Edge ..	1200	1830	18		
Summit..... „ „ ..	1200	1830	11	14.3	9
Whitehaven..... Cumberland..	90	1845	3	16.1	11
Cockermouth		1845	3	13.0	11
Keswick .....Westmoreland ..	258	1845	3	19.9	16
Grasmere..... „ ..	180	1845	3	48.0	25
Seathwaite .... „ ..		1845	3	55.8	32
Gatesgarth .... „ ..	326	1845	3	44.8	28
Styehead ..... „ ..	1290	1846	2	20.0	27
Sparkling Tarn „ ..	1900	1846	2	22.0	48
Great Gable.... „ ..	2925	1849	2	10.0	43
Newcastle-upon-Tyne	121	1846	2	5.3	6
West Denton, near ditto	276	1845	5	9.1	13
Allenheads „	1300	1843	7	15.6	15
Applegarth.....Dumfries..		1838	12	10.4	9
Gilmourton .....Lanark..	600	1845	5	18.8	11
Glasgow	8	1848	2	15.5	8
Edinburgh	300	1825	21		
Glencorse (Pentland Hills)	734	1831	19	11.6	10

The above Tables give the average maximum and minimum, for peri
with the total for each year of the three periods.

The *Winter* period is for *November*, *December*, *January* and
The *Spring* „ *March*, *April*, *May* and *June*.
The *Summer* „ *July*, *August*, *September* and *Octob*

GREAT BRITAIN.

	Maximum.				Minimum.				
TER.	Spring.	Summer.	Total 12 mos.	Year of Maxim.	Winter.	Spring.	Summer.	Total 12 mos.	Year of Minimum
s.	Ins.	Ins.	Ins.	A.D.	Ins.	Ins.	Ins.	Ins.	A.D.
.2	16.7	15.0	53.9	1828	19.5	4.7	10.5	34.7	1826
			51.9	1841				32.0	1840
			57.3	1841				37.9	1844
.5	14.1	19.4	45.4	1829	6.3	10.0	11.6	27.9	1830
.0	15.6	27.5	70.1	1839	19.8	9.3	12.5	41.6	1844
.3	12.4	18.0	41.7	1841	10.3	6.3	8.9	25.5	1844
.2	12.4	12.7	39.2	1828	6.9	8.4	8.7	24.0	1830
			37.8	1842					
			34.07	1848				19.28	1847
.0	11.4	12.4	32.8	1848	8.1	3.3	9.8	21.2	1844
.7	8.7	9.9	34.3	1828	6.9	8.4	8.7	24.0	1830
			43.53	1848				22.36	1847
.2	7.0	13.5	29.7	1846	4.8	4.7	5.7	15.2	1847
.6	10.6	12.5	31.7	1848	5.3	5.0	6.5	16.8	1847
			33.2	1841				16.4	1840
.5	7.2	13.4	29.1	1816	6.1	7.7	5.5	19.3	1814
.5	8.6	18.1	32.2	1829	5.6	7.4	9.5	22.5	1832
			34.7	1848				22.5	1847
.1	10.4	14.8	33.3	1848	5.8	3.3	8.7	17.8	1844
.0	10.1	12.6	29.7	1843	3.6	8.1	7.9	19.6	1842
			32.4	1848				18.4	1847
			25.8	1843				20.0	1845
.3	6.7	14.8	28.8	1829	5.7	3.2	7.2	16.1	1834
.9	12.2	16.4	38.5	1848	7.2	4.9	8.0	20.1	1844
			52.3	1841				33.0	1844
.0	12.8	13.8	39.6	1833	9.2	11.0	10.4	30.6	1832
			49.5	1841				22.2	1826
.4	11.2	20.5	45.1	1823	14.2	3.9	12.2	30.3	1826
			40.7	1845				24.8	1842
.0	11.3	31.3	58.6	1831	19.2	7.6	15.4	42.2	1837
			50.6	1833				28.6	1844
.7	9.5	9.6	30.8	1833	8.8	10.0	7.7	26.5	1832
			40.2	1836				26.1	1832
.9	2.5	10.3	37.7	1834	6.8	8.4	10.7	25.9	1831
			61.1	1836				34.4	1844
			47.4	1833				24.8	1844
.6	9.3	12.6	55.5	1834	8.4	8.7	15.6	32.7	1831
.2	11.9	23.9	52.0	1846	10.3	10.3	14.4	35.0	1847
.2	13.3	25.9	55.4	1846	9.8	9.1	16.0	34.9	1847
.7	19.5	29.1	74.3	1846	14.1	13.3	19.6	47.0	1847
.8	7.1	7.4	19.3	1846	5.7	7.5	3.6	15.8	1847
.7	13.6	15.0	36.4	1846	11.6	11.6	8.3	31.5	1847
.2	16.0	19.3	58.5	1848	13.1	10.5	14.7	38.3	1844
.4	9.3	23.4	44.1	1839	6.9	7.5	9.6	24.0	1847
.5	13.7	21.1	60.3	1846	8.8	12.8	13.7	35.3	1847
.4	8.1	9.4	33.9	1849	14.7	8.5	10.3	33.5	1848
			32.59	1827				15.27	1826
.5	14.2	17.2	45.9	1836	5.4	10.0	8.1	23.5	1847

here years only are given, the details have not been accessible to the author. The rvations are all from authentic data, many kindly furnished from private sources. Lancashire observations are from Mr. Homersham's reports; the Cumberland and moreland from Mr. Miller, of Whitehaven; Nottingham from Mr. Lowe; Welling-igh from Mr. Bevan, C.E.; Cobham Lodge from Miss Molesworth's diurnal observations.

DETAIL OF MONTHLY RAIN

	Year.	January.		February.		March.		April.		May.		
		Total fall.	Heavy fall.	Total fall.	Heavy fall.	Total fall.	Heavy fall.	Total fall.	Heavy fall.	Total fall.	Heavy fall.	To fa
		Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	In
Glencorse.	1831	.89	..	3.92	3.09	3.29	2.10	2.04	.57	.82	..	2.
	1832	.96	.42	1.75	.88	2.23	1.00	1.53	.80	2.00	1.15	4.
	1833	.78	.37	4.31	3.22	3.40	1.85	2.75	1.20	1.30	.96	6.
	1834	6.05	3.62	2.31	.97	3.69	3.01	1.31	.43	1.15	.33	2.
	1835	2.07	.85	3.52	2.34	4.08	3.72	1.13	0.59	3.14	1.87	1.
	1836	6.24	5.58	1.99	1.50	7.32	5.61	2.11	.43	.63	.33	4.
	1837	2.81	2.15	3.22	.94	3.10	2.42	3.07	2.46	1.54	.63	2.
	1838	2.39	2.26	1.92	1.92	3.12	2.17	3.01	2.41	3.93	3.33	5.
	1839	3.88	3.77	3.45	2.71	3.72	2.64	.57	.41	1.47	.81	4.
	1840	6.20	5.34	2.58	1.53	.65	..	.35	..	4.35	3.04	3.
	1841	2.11	1.84	1.18	..	1.95	.78	1.86	.31	1.74	..	2.
	1842	1.32	..	1.89	1.07	4.31	3.52	..	..	2.12	.80	1.
	1843	3.51	3.12	2.05	2.04	.99	..	2.66	1.88	3.61	1.87	2.
	1844	2.54	1.83	3.04	2.98	3.82	3.63	.81	.39	.71	.37	3.
	1845	3.29	2.69	1.33	1.26	2.08	1.57	1.51	.35	2.94	1.34	4.
	1846	2.75	1.63	3.24	2.25	2.75	1.49	2.93	.91	2.42	1.56	4.
	Average	2.98	2.21	2.60	1.80	3.15	2.22	1.73	.82	2.12	1.15	3.
Gilmourton.	1845	4.30	3.75	2.10	1.75	3.00	2.30	1.80	.40	2.20	.40	4.
	1846	5.50	4.30	3.40	2.90	5.20	4.15	1.50	.30	2.20	1.45	4.
	1847	2.10	1.69	2.10	1.50	1.45	1.20	4.00	3.40	4.10	3.20	3.
	Average	3.97	3.25	2.53	2.05	3.22	2.55	2.43	1.37	2.83	1.68	4.
Boston.	1831	1.67	1.15	2.50	1.65	1.13	.32	0.90	.72	0.98	.77	1.
	1832	.77	..	.12	..	1.47	.67	1.60	1.35	2.70	1.95	3.
	1833	.64	0.00	4.54	2.58	2.26	.89	2.30	.63	.53	..	3.
	1834	2.41	.65	.45	..	.36	..	.64	..	.81	..	1.
	1835	1.72	.76	2.00	.39	2.68	.79	1.79	.73	2.10	.96	2.
	1836	1.11	..	1.87	1.04	2.24	..	1.60	.34	.47	..	1.
	1837	3.26	2.26	1.47	.36	.41	.35	2.00	1.08	1.08	..	1.
	1838	1.00	.90	1.62	.72	1.09	.	1.68	.79	1.88	.69	2.
	1839	1.40	.50	1.10	.51	2.59	1.99	.75	.30	.66	..	4.
	1840	1.25	.36	1.28	..	.70	.31	.54	..	2.46	1.19	1.
	1841	1.55	.85	1.58	.58	1.20	.32	1.69	.68	1.42	.72	3.
	1842	2.40	2.40	1.48	.31	2.08	.72	1.34	.87	2.48	1.22	1.
	1843	1.34	.36	2.16	1.34	.62	..	1.39	1.54	3.80	2.89	1.
	1844	1.68	.40	1.80	1.16	1.89	.65	.39	..	.52	.35	1.
	1845	1.42	.68	.90	..	1.98	1.51	1.12	.34	3.37	2.14	2.
	1846	2.50	1.32	.57	..	.64	..	3.23	2.32	1.45	0.40	1.
	1847	.98	..	1.21	.87	.94	.37	1.77	.36	5.41	3.75	2.
	Average	1.59	.740	1.56	.674	1.42	.523	1.42	.709	1.89	.999	2.

AVERAGE OF RAIN FOR 1844, 1845, 1846 & 1847,

Amounting to .4 inch and upwards in 24 hours; from Mr. Homersham's Report on of Water to Manchester.

Locality.	Above Sea.	Rain per Ann.	Ditto .4 in. and above.	Days of .4 in. and above.	Total I of Rai
Manchester	120	36.49	16.25	26	206
Marple	531	36.56	20.00	31	122
Combs	720	45.80	27.60	43	160
Chapel-en-le-Frith	1121	39.92	21.80	38	136

GREATEST DEPTH IN ONE DAY.

	1844.	1845.	1846.	1847.
Manchester	1.36	1.48	0.77	1.20
Marple	2.90	2.10	0.80	2.30
Combs	1.50	2.00	1.00	2.00
Chapel-en-le-Frith	1.10	1.70	1.20	1.30
Glencorse, October 3rd	..	2.14	3.37 July 6th.	
Gilmourton	„	1.50	2.50	„

Note.—There fell without intermission, on June 23 and 24, 1846, at Glencorse 1.83 inches; at Gilmourton 1.50 and 1.50 inches.

PROPORTION OF HEAVY FALL.

July.		August.		Sept.		Oct.		Nov.		Dec.				
al l.	Hvy. fall.	Total fall.	Hvy. fall.	Total fall.	Hvy. fall.	Total fall.	Hvy. fall.	Total fall.	Hvy. fall.	Total fall.	Hvy. fall.	Total Annl. fall.	Total Heavy fall.	Total No. of Days Heavy fall.
s.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	
98	2.22	3.93	3.27	2.45	1.24	3.76	1.82	3.20	1.61	2.00	.38	31.36	16.62	33
52	1.05	6.55	5.41	1.31	..	7.83	6.64	1.83	1.14	3.67	2.49	35.71	22.25	34
22	2.48	1.91	1.07	2.13	1.27	2.32	1.90	3.10	1.50	8.28	6.55	39.70	26.62	46
13	4.52	1.85	.63	5.29	4.32	3.17	2.04	2.92	2.08	2.70	2.28	37.72	24.78	39
29	.89	2.64	2.14	7.48	5.82	4.85	3.18	3.59	2.10	2.66	1.87	39.11	25.69	43
55	6.33	2.73	2.23	3.88	2.57	2.73	1.92	4.78	4.08	4.72	3.70	49.08	36.98	56
22	4.84	5.12	4.69	2.74	2.34	5.50	4.20	2.46	1.12	3.40	2.29	41.61	29.95	48
50	.12	4.33	3.67	4.84	4.13	3.46	3.29	3.20	2.90	1.70	.59	40.45	31.98	48
30	3.77	3.06	1.54	3.88	2.31	2.90	2.08	3.13	2.15	2.10	1.28	36.86	26.85	45
45	3.69	2.50	1.62	4.23	2.28	2.26	1.38	3.89	3.06	1.13	.39	36.70	23.85	41
41	2.19	5.50	4.27	3.25	1.43	6.65	5.08	2.68	2.03	4.65	4.15	38.51	23.52	41
85	.70	1.86	1.01	2.73	1.72	1.56	1.14	2.05	1.28	4.22	3.22	25.67	15.84	33
24	3.21	2.44	.51	1.35	.57	5.23	3.67	4.05	2.34	.94	5.05	33.34	25.72	33
51	1.82	2.26	.95	2.99	2.18	1.78	.90	5.59	4.44	.20	..	30.12	21.80	40
54	1.01	5.38	3.71	4.83	4.02	8.01	7.45	2.90	1.50	4.43	3.25	43.63	31.34	51
59	4.21	5.30	4.59	1.99	1.18	3.84	2.55	2.08	1.05	1.02	.77	38.45	25.92	38
95	2.69	3.58	2.58	3.46	2.33	4.12	3.08	3.21	2.15	3.00	2.39	37.38	25.61	41.7
80	1.95	4.10	2.37	5.80	5.15	11.70	11.35	7.80	7.10	9.80	9.20	59.60	48.87	74
10	4.90	6.30	5.90	2.50	2.05	5.20	3.80	2.40	1.40	2.20	1.55	47.30	37.10	63
10	1.50	1.30	.40	4.40	2.60	5.90	4.90	6.00	4.95	4.50	3.20	41.25	31.24	62
57	2.78	3.90	2.89	4.23	3.60	7.60	6.68	5.40	4.48	5.50	4.65	49.38	39.07	66.3
85	1.55	5.03	4.54	2.90	2.12	2.46	1.19	1.95	.82	1.96	.38	25.57	15.88	30
55	1.00	3.89	2.14	.90	.49	1.85	1.08	2.59	.90	2.03	.32	22.55	9 73	25
50	.30	2.02	1.04	1.49	.63	2.23	1.49	.86	.67	1.98	.30	22.62	11.89	23
84	3.18	1.39	.92	1.30	.75	.67	..	.79	.50	.64	.32	14.66	6.67	12
80	.87	0.84	.40	2.61	1.62	3.58	2.64	1.74	.72	.27	..	22.57	11.23	25
50	.34	1.22	.33	2.38	.68	2.73	1.95	3.46	1.93	1.22	.78	21.38	7.79	16
88	.83	3.90	3.05	1.70	.86	1.96	1.06	1.55	.34	2.58	1.29	23.58	12.44	21
54	..	2.85	1.33	1.82	1.03	1.35	.92	1.17	.30	0.79	.34	18.95	8.09	16
36	3.50	3.47	2.28	2.16	.42	2.41	1.31	3.23	2.07	1.77	.35	28.48	16.64	29
76	1.54	1.22	.40	1.90	.78	1.63	.58	2.03	.46	.85	..	18.61	6.01	14
74	1.92	2.85	1.92	3.43	2.19	2.97	1.62	2.11	.98	1.67	..	27.26	14 20	27
57	2.66	1.05	.64	3.72	2.20	.88	..	3.80	2.87	.88	.63	24.73	14.03	21
40	1.37	4.02	2.92	0.47	..	3.35	1.61	2.84	1.67	.12	..	24.29	14.89	30
63	1.49	2.57	1.67	2.50	1.54	2.37	1.58	3.40	2.85	.40	..	21.64	12.48	24
51	.78	4.85	3.82	1.26	.73	1.39	.69	1.13	.32	2.32	.73	24.29	12.87	28
98	1.22	3.08	2.44	.79	.37	4.38	2.64	1.70	1.18	2.00	1.46	23.40	14.28	29
86	.68	1.46	.79	1.54	.88	2.52	1.78	1.32	.53	3.06	2.14	23.92	13.65	23
32	1.37	2.64	1.80	1.93	1.02	2.28	1.30	2.10	1.06	1.44	.53	22.30	11.93	23.11

The above Table shows the quantity of rain in each month of the years specified, placed in juxtaposition with the amount of rain given by falls of ·3 inch and upwards, as extracted from the diurnal registries.

The places are Glencorse in the Pentland Hills, 734 feet above the sea.
" Gilmourton " Avondale " 600 " "
" Boston, Lincolnshire, about 40 " "

The two former give fair specimens of rain-fall in ordinary hill districts. The last gives the average rain in the flat central parts of Great Britain.

RAINFALL OF GREAT BRITAIN.

DETAILS OF MONTHLY FALL.

From the Quarterly Returns compiled by James Glaisher, F.R.S.

Period.		Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Guernsey. Height 123 feet above the Sea.	1852	5.4	1.0	1.0	0.8	2.7	3.6	3.5	3.4	5.4	7.5	8.4	6.4	49.1
	1853	5.4	3.0	1.6	2.8	1.1	2.7	2.2	3.3	4.2	4.2	2.3	2.0	34.8
	1854	3.3	0.8	0.4	0.2	4.1	3 3	1.0	1.5	1.3	7.2	4.1	3.0	30.2
	1855	1.0	2.9	3.0	0.3	3.0	2.8	4.3	0.6	2.6	6.0	2.0	2.0	30.5
	1856	4.4	1.9	0.8	4.0	3.0	1.9	2.8	2.4	3.7	2.6	1.6	4.9	34.0
	1857	5.1	0.5	1.6	3.6	1.3	1.8	1.3	1.2	4.5	5.7	3.8	1.3	31.7
	1858	1.0	1.4	2.1	1.7	1.9	0.6	3.1	0.8	2.6	1.8	3.3	5.3	25.6
	1859	2.5	3.3	1.7	3.1	3.0	2.3	1.0	1.3	6.8	6.2	7.1	5.1	43.4
	1860	6.6	2.1	2.2	2.0	4.0	5.0	1.7	6.0	3.8	3.3	4.2	6.6	47.5
	Mean	3.8	1.9	1.6	2.0	2.7	2.7	2.3	2.3	3.9	4.9	4.1	4.1	36.3
Falmouth. Height 120 feet.	1852	7.2	1.5	1.3	1.8	3.7	3.6	0.9	4.5	4.0	6.7	10.2	4.7	50.1
	1853	5.0	1.8	2.3	2.5	0.6	3.9	3.7	3.1	3.3	5.1	4.9	2.9	39.1
	1854	6.1	1.6	1.0	0.8	3.5	3.9	1.2	1.2	1.3	5.8	3.0	2.3	31.7
	1855	0.1	3.4	4.6	0.7	4.8	4.1	2.7	2.4	0.5	4.8	1.3	2.9	32.3
	1856	4.3	3.1	1.8	5.8	2.9	1.9	1.7	1.4	3.2	5.2	2.2	6.1	39.6
	1857	4.7	2.0	4.7	5.0	2.2	1.7	3.8	2.5	2.7	6.4	3.4	1.9	41.0
	1858	0.6	3.6	0.7	5.5	2.3	0.5	3.8	2.7	3.4	3.7	3.3	6.1	36.2
	1859	3.8	2.2	3.6	4.0	2.2	1.3	1.0	4.3	5.2	6.1	3.6	5.8	43.1
	1860	6.1	1.7	2.5	1.3	4.0	7.4	1.6	5.8	3.9	2.7	4.2	7.0	48.2
	Mean	4.2	2.3	2.5	3.1	2.9	3.1	2.3	3.1	3.1	5.1	4.0	4.4	40.1
Torquay. Height 120 feet.	1852	4.7	1.1	1.4	1.3	2.5	6.5	1.0	3.6	5.1	5.7	10.6	6.7	50.2
	1853	4.4	3.2	0.9	1.6	3.6	3.3	2.7	2.5	1.3	4.8	2.8	3.6	34.7
	1854	3.9	0.8	0.3	0.3	2.9	1.9	1.1	0.5	0.8	2.6	3.2	1.1	19.4
	1855	2.0	0.4	2.9	0.4	2.4	2.5	3.2	1.4	0.5	3.6	1.0	2.6	22.9
	1856	1.5	2.8	0.7	3.5	2.5	1.1	0.4	3.5	2.3	3.1	1.8	3.6	26.8
	1857	2.3	1.3	3.1	2.1	2.8	2.5	1.2	1.0	1.3	4.7	1.8	0.8	24.9
	1858	0.6	1.6	0.8	4.1	0.9	1.1	3.2	0.8	1.7	3.3	3.5	3.8	25.4
	Mean	2.8	1.6	1.4	1.9	2.5	2.7	1.8	1.9	1.9	4.0	3.5	3.2	29.2
Clifton. Height 228 feet.	1853	3.0	0.7	0.5	3.1	2.3	4.4	4.8	4.5	3.3	3.9	2.9	0.6	34.0
	1854	3.2	1.0	0.7	0.0	3.4	3.1	2.5	1.3	1.1	3.3	1.0	2.0	22.6
	1855	0.3	1.5	2.2	0.4	2.2	3.6	3.5	2.8	0.8	6.0	0.5	1.0	24.8
	1856	3.4	1.9	1.2	3.5	3.1	1.7	1.7	4.7	5.2	2.7	0.7	2.4	32.2
	1857	2.7	1.5	1.9	2.9	2.1	2.1	2.5	4.0	2.2	3.3	1.7	1.1	28.0
	1858	1.0	1.2	1.1	2.9	2.5	2.0	1.7	1.7	3.3	2.7	1.5	2.7	24.3
	1859	2.0	1.6	4.7	3.0	2.4	1.2	3.9	3.9	3.6	2.2	3.0	3.8	36.0
	1860	4.5	1.0	2.1	1.7	3.5	7.1	1.9	5.7	2.4	3.0	2.8	3.8	39.5
	Mean	2.5	1.3	1.8	2.2	2.7	3.2	2.8	3.6	2.7	3.4	1.8	2.2	30.2
Lampeter. Height 420 feet.	1856	4.5	3.7	1.0	4.6	2.4	1.8	1.8	2.7	5.0	4.0	3.4	6.0	40.9
	1857	4.7	3.4	4.8	4.6	1.9	2.0	3.3	2.2	4.1	3.8	1.7	2.4	38.9
	1858	2.2	0.6	2.5	4.4	3.2	2.1	2.3	2.3	3.8	6.1	2.0	5.2	36.7
	1859	3.5	2.6	4.7	3.5	1.0	1.5	1.6	3.5	5.9	4.7	6.2	5.6	44.3
	1860	6.6	2.0	5.3	2.5	2.7	7.5	4.0	8.6	3.4	4.6	3.3	4.8	55.5
	Mean	4.3	2.5	3.7	3.9	2.2	3.0	2.6	3.9	4.4	4.6	3.3	4.8	43.2
Hawarden. Height 260 feet.	1852	3.7	2.9	1.0	0.4	2.4	4.4	2.9	4.2	5.3	3.5	5.9	3.8	40.4
	1853	2.6	1.0	1.8	1.7	1.4	4.0	6.3	2.6	2.1	3.1	1.5	1.0	29.1
	1854	1.6	1.1	0.7	0.7	1.7	1.6	2.0	2.2	1.1	1.9	2.9	2.8	20.3
	1855	0.4	1.6	1.8	0.5	1.3	3.1	5.4	2.3	0.7	3.5	0.4	1.2	22.2
	1856	2.9	1.4	0.9	1.6	2.3	1.6	2.8	2.6	4.1	2.4	1.7	1.7	26.0
	1857	2.8	0.9	2.4	2.9	2.9	3.2	2.2	4.8	2.1	1.9	1.8	0.4	28.3
	1858	0.3	0.4	1.0	3.6	2.3	2.4	1.6	1.6	2.2	2.7	1.7	2.2	22.0
	1859	0.7	2.1	2.8	3.3	1.7	2.5	4.0	2.6	2.4	3.4	2.2	2.3	30.0
	1860	2.4	0.5	2.5	0.9	1.9	4.2	1.3	5.0	1.4	2.0	2.0	3.7	27.8
	Mean	1.9	1.3	1.7	1.6	2.0	3.0	3.2	3.1	2.4	2.7	2.2	2.1	27.2

RAINFALL OF GREAT BRITAIN.

DETAILS OF MONTHLY FALL.

From the Quarterly Returns compiled by JAMES GLAISHER, F.R.S.

Period.		Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Oxford ..... Height 210 feet above the Sea.	1850	1.0	2.0	1.2	2.3	2.1	1.9	5.1	1.2	1.7	1.6	1.9	2.2	24.2
	1851	2.9	0.8	3.5	1.3	1.0	1.7	3.9	2.3	0.4	2.5	0.7	1.0	22.0
	1852	5.3	1.0	0.6	0.6	2.1	7.1	2.8	4.5	3.1	2.7	7.1	3.5	40.4
	1853	2.5	1.2	1.0	2.4	2.3	3.2	3.4	2.8	2.0	4.0	2.0	0.4	27.2
	1854	2.1	0.9	0.4	0.8	3.2	1.8	1.5	1.8	0.4	2.3	1.3	1.2	17.7
	1855	0.3	1.3	2.2	0.4	1.8	2.4	5.1	1.7	2.4	5.6	1.0	1.1	25.2
	1856	2.9	1.3	0.9	2.6	4.3	2.6	0.6	3.2	3.2	2.4	0.9	2.0	27.0
	1857	3.1	0.3	1.4	2.2	1.2	2.9	3.3	2.9	3.4	4.5	1.6	0.7	27.5
	1858	0.7	1.8	0.8	3.6	2.3	1.6	2.6	2.0	2.3	2.0	0.8	2.0	22.5
	1859	0.8	1.7	1.5	2.5	1.7	2.2	2.8	3.8	3.5	2.7	2.0	1.8	27.0
	1860	3.3	1.3	1.9	0.6	2.8	5.1	2.4	3.8	2.5	1.6	3.2	2.6	31.1
Mean 25 Years		1.99	1.83	1.81	1.94	2.17	2.34	2.51	2.63	2.67	2.63	2.47	2.23	27.2
Max. Fall in 24 Hours	1855	0.18	0.61	0.52	0.26	0.45	0.80	1.65	0.46	0.77	0.83	0.53	0.43	
	1856	0.46	0.30	0.53	0.62	0.58	0.38	0.17	0.87	0.60	0.57	0.45	0.31	
Distribution under		.05	.10	.20	.30	.40	.50	.60	.70	.80	.90	1.0	1.5	
For Days in.....	1854	73	30	27	9	9	4	1	...	2	...	1	...	156
	1855	58	18	26	9	6	5	8	4	2	2	2	...	140
	1856	49	24	30	22	13	4	5	2	1	1	...	2	153
Mean No. of Days' for 25 Years Rain ...		10.1	10.1	9.3	9.8	9.5	11.5	11.4	11.3	10.9	11.8	12.2	11.5	129
Birmingham. Height 380 feet.	1839	1.4	2.0	1.9	1.6	0.5	4.5	4.3	2.6	2.8	2.3	3.8	1.3	29.2
	1840	2.7	2.0	0.1	0.5	2.4	2.0	2.3	2.1	1.7	1.0	4.1	1.8	22.9
	1841	2.0	1.3	2.1	1.5	2.0	2.1	2.5	3.3	4.7	3.1	2.3	0.3	27.2
	1842	2.0	1.3	2.7	0.5	2.5	1.1	2.8	1.7	3.0	0.9	4.5	3.8	26.8
	1843	1.7	2.7	1.0	1.9	3.9	2.6	1.7	3.1	0.7	1.1	2.8	0.8	27.3
	1844	1.4	3.1	2.6	0.3	0.2	0.5	1.9	2.3	2.0	2.4	2.8	0.3	19.9
Mean 8 Years		1.9	2.2	1.6	1.3	1.9	2.1	2.6	2.6	2.3	2.3	3.2	1.4	25.4
Evaporation at Birmingham... and Mean Temp. of Fah.	1843	1.94	1.05	1.87	3.16	3.49	3.65	4.23	3.92	3.32	2.62	1.51	1.41	32.2
	1844	1.58	0.95	2.94	3.76	4.87	5.38	4.77	4.23	3.00	2.20	1.21	0.28	35.1
	1843	39.7	33.5	44.0	48.0	53.5	56.7	62.0	64.2	57.7	47.7	42.5	45.0	49.6
	1844	37.0	33.7	42.2	51.2	50.5	62.5	66.2	63.5	62.5	46.5	43.5	42.0	50.1
Norwich ..... Height 39 feet.	1850	1.9	1.3	1.3	1.8	2.9	0.6	6.5	1.8	1.9	2.5	2.9	2.4	27.8
	1851	2.4	1.0	3.2	3.0	1.2	2.0	3.66	3.05	1.12	3.12	5.91	0.72	30.4
	1852	3.4	3.3	0.6	0.4	1.4	3.1	0.8	3.5	5.2	3.9	5.2	2.0	32.8
	1853	2.3	3.4	1.3	2.7	0.6	2.2	4.5	3.1	1.5	3.2	1.3	1.3	27.4
	1854	0.5	1.4	0.5	0.7	4.8	0.4	2.0	4.8	0.7	2.4	2.7	3.2	24.1
	1855	1.1	1.9	1.2	0.3	1.3	2.7	3.5	1.4	0.8	3.7	3.3	1.9	23.1
	1856	3.0	1.4	0.5	1.3	3.1	1.0	2.7	2.6	3.6	2.2	2.7	1.3	25.4
	1857	3.6	0.1	0.9	2.5	0.9	2.6	0.5	2.4	4.9	2.8	1.5	0.4	23.1
	1858	0.4	0.6	1.1	1.5	2.0	1.0	3.8	2.4	0.8	2.8	1.7	2.2	20.3
	1859	0.5	1.1	1.3	3.6	1.0	1.5	2.1	2.0	3.2	2.9	2.3	2.8	24.3
	1860	2.8	1.6	2.9	1.4	3.6	4.5	2.4	3.5	3.4	1.8	3.3	2.0	33.2
	Mean	2.0	1.6	1.3	1.7	2.1	2.0	3.0	2.7	2.4	2.8	3.0	1.8	26.5
York ..... Height 50 feet.	1852	2.4	0.7	0.5	0.3	0.9	3.5	1.8	2.5	4.3	3.8	4.2	2.4	27.3
	1853	1.9	2.5	1.4	1.5	0.8	2.5	2.5	1.2	2.2	3.0	2.1	0.8	22.4
	1854	2.0	0.4	0.9	0.5	2.2	2.9	2.6	1.2	0.8	1.0	2.5	1.5	18.5
	1855	1.0	1.5	1.2	0.2	0.9	2.0	4.1	3.3	0.3	2.9	1.2	0.9	19.5
	1856	2.2	1.4	0.4	2.7	3.9	1.5	2.3	4.2	3.0	1.7	1.0	2.1	26.4
	1857	2.6	0.6	2.1	2.8	1.5	2.7	2.9	6.6	2.0	1.2	1.1	0.3	26.4
	1858	0.5	0.7	1.1	1.2	1.7	0.9	2.6	3.4	3.3	2.4	1.3	1.5	20.6
	1859	1.1	1.0	1.6	2.4	0.4	1.7	2.4	2.6	2.1	2.0	1.6	1.7	20.7
	1860	2.2	2.0	2.2	1.2	3.3	2.8	2.3	3.7	2.9	1.5	2.1	3.2	29.4
	Mean	1.8	1.2	1.3	1.4	1.7	2.2	2.6	3.2	2.3	2.2	1.9	1.6	23.4

RAINFALL OF GREAT BRITAIN.

DETAILS OF MONTHLY FALL.

From the Quarterly Returns compiled by James Glaisher, F.R.S.

Period.		Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Liverpool. Height 37 fee above the Sea.	1852	2.8	2.7	0.4	0.2	1.4	2.6	3.1	4.5	1.8	3.7	4.6	3.4	31.2
	1853	2.3	0.6	0.8	1.2	1.4	3.1	4.1	4.4	1.6	2.9	1.7	0.5	24.6
	1854	1.7	1.5	0.7	1.0	0.9	2.1	2.8	2.4	1.8	2.3	3.1	2.5	22.8
	1855	0.5	1.1	1.9	0.4	1.4	3.0	5.2	2.7	0.7	3.9	0.5	1.1	22.4
	1856	2.9	1.2	0.7	1.7	1.5	1.9	3.2	1.8	3.1	1.5	2.0	1.9	23.4
	1857	1.8	0.7	2.0	2.2	2.2	3.8	2.3	3.1	2.9	2.1	1.5	1.4	27.0
	1858	1.0	0.1	1.5	2.5	1.7	2.1	2.0	1.8	3.2	4.0	1.6	2.8	24.3
	1859	0.6	1.6	2.4	3.0	0.5	2.1	1.2	4.0	3.0	3.4	1.5	2.3	25.6
	1860	2.1	0.7	2.2	0.9	1.8	3.5	1.5	6.0	1.7	2.4	1.0	2.9	26.7
	Mean	1.7	1.4	1.4	1.4	1.4	2.7	2.8	3.4	2.2	2.9	1.9	2.1	25.3
Stonyhurst. Height 381 feet.	1852	8.5	8.1	0.4	0.4	2.8	3.8	3.7	5.7	4.6	6.1	6.6	8.6	59.3
	1853	4.9	1.3	1.7	3.7	0.3	4.6	7.3	3.1	4.2	4.1	3.3	0.8	39.3
	1854	3.8	4.3	1.9	1.1	2.7	2.9	2.6	4.4	5.0	4.2	4.8	8.7	46.4
	1855	1.3	0.9	3.1	2.7	2.0	5.1	4.9	3.3	1.7	9.5	1.2	1.9	37.6
	1856	2.7	6.1	0.5	2.8	3.2	5.7	3.6	5.1	4.1	1.4	2.4	6.4	44.0
	1857	4.0	2.8	3.2	2.1	2.5	6.9	4.3	4.0	3.0	2.2	1.8	4.1	40.9
	1858	2.5	0.3	2.9	3.0	3.6	2.0	4.0	3.6	6.1	6.4	2.5	4.8	41.7
	1859	4.0	3.9	6.5	4.2	0.8	3.2	1.9	5.8	7.7	3.5	3.0	3.1	47.6
	1860	2.7	1.8	6.1	1.7	4.2	6.4	3.6	6.4	3.5	7.7	2.8	3.5	50.4
	Mean	3.8	3.3	2.9	2.4	2.4	4.5	4.0	4.6	4.4	5.0	3.2	4.7	45.2
Southampton. Height 60 feet.	1852	5.9	1.3	0.7	0.6	2.7	5.4	2.2	4.3	4.8	6.5	10.0	4.3	48.7
	1853	5.5	0.2	0.8	3.1	2.2	2.9	2.4	2.2	1.5	6.1	1.6	0.4	28.9
Worthing. Height 25 feet.	1856	2.6	1.6	1.2	3.5	3.3	2.3	1.8	3.1	4.5	2.4	1.4	3.1	30.8
	1857	1.8	0.2	1.5	1.5	1.0	2.1	1.0	4.4	3.0	4.4	2.6	0.6	24.1
	1858	0.8	1.4	0.6	2.5	0.9	0.6	2.1	1.7	1.4	1.6	1.6	3.6	18.8
	1859	0.8	2.5	1.5	2.3	2.3	2.0	1.4	0.5	3.6	4.1	4.8	3.7	29.5
	1860	4.6	0.7	1.8	1.8	3.5	5.0	1.8	3.7	3.0	2.5	2.8	3.3	34.5
	Mean	2.1	1.4	1.3	2.3	2.2	2.4	1.6	2.7	3.1	3.0	2.6	2.8	27.5
Hartwell, Aylesbury. Height 250 feet.	1852	4.4	0.9	0.4	0.6	1.8	4.2	1.5	5.0	3.0	3.0	6.0	2.6	33.8
	1853	1.9	1.5	2.2	1.8	1.8	4.3	3.9	3.2	1.9	3.2	1.5	0.8	28.0
	1854	2.2	0.8	0.5	0.5	2.7	0.7	1.0	1.6	0.4	2.0	1.0	1.6	15.0
	1855	0.5	1.3	1.9	0.3	1.4	1.9	3.9	2.2	1.4	5.2	1.1	0.9	22.0
	1856	2.4	1.3	0.7	1.7	3.7	1.6	2.6	2.6	2.7	1.7	1.3	2.0	24.3
	1857	3.6	0.2	1.2	1.7	0.5	2.5	1.9	2.8	3.2	4.9	1.4	0.4	24.3
	1858	0.6	1.5	0.7	2.9	2.1	0.2	1.9	1.4	0.8	1.6	0.7	2.8	17.2
	1859	0.9	1.7	2.9	3.2	1.4	2.0	1.6	3.7	2.5	2.4	1.9	1.1	25.3
	1860	2.1	0.8	1.9	1.2	4.1	4.9	1.2	4.7	3.6	1.9	2.5	2.6	32.3
	Mean	2.1	1.1	1.4	1.6	2.2	2.5	2.2	3.0	2.1	2.9	1.9	1.6	24.6
Bedford. Height 100 feet.	1852	3.4	1.1	0.5	0.3	2.3	3.3	2.9	5.9	2.7	2.4	5.4	2.1	32.3
	1853	1.8	1.3	0.8	2.5	1.4	3.1	2.9	2.1	1.1	2.2	1.5	0.8	21.7
	1854	2.5	0.7	0.4	0.5	3.1	1.0	2.3	2.2	0.5	1.6	1.4	1.6	17.9
	1855	0.4	1.5	1.1	0.5	1.5	3.5	3.2	1.2	1.1	3.8	2.0	0.8	20.8
	1856	1.8	0.9	0.6	1.3	2.1	1.6	1.1	3.0	1.7	1.7	1.1	1.4	18.6
	1857	2.8	0.2	1.4	2.2	1.2	2.5	2.0	3.2	3.2	5.2	1.3	0.0	25.4
	1858	0.5	1.4	0.7	3.3	2.3	0.6	1.9	3.1	1.5	2.1	0.8	1.8	20.0
	1859	0.6	1.3	1.3	1.8	2.3	2.5	2.2	2.7	1.9	2.7	1.7	1.8	23.0
	1860	2.5	1.2	1.5	0.7	3.2	4.3	0.9	3.1	2.5	1.3	2.0	1.6	24.9
	Mean	1.9	1.0	1.1	1.4	2.1	2.4	2.3	2.9	1.7	2.5	1.8	1.2	22.3
Nottingham. Height 203 feet.	1852	3.7	1.9	0.7	0.6	1.3	4.9	3.0	3.4	5.6	3.0	7.2	2.1	37.4
	1853	3.0	1.1	0.7	1.8	1.0	5.0	2.9	4.3	2.1	3.3	2.6	0.6	28.4
	1854	2.9	0.8	0.5	0.5	2.2	1.0	2.1	1.4	0.9	0.9	1.8	2.4	17.4
	1855	0.5	1.5	1.1	1.0	1.9	2.4	4.6	1.1	0.7	4.7	1.0	0.8	21.3
	1856	2.9	1.9	1.0	2.4	3.8	1.5	2.6	4.0	2.6	3.8	1.9	1.8	30.2
	1857	3.2	0.7	1.9	3.1	1.1	3.2	1.7	6.2	3.0	2.3	1.4	0.5	28.3
	1858	0.2	0.3	0.8	2.4	1.4	1.3	1.2	3.0	2.3	3.4	0.7	1.9	18.9
	1859	0.7	1.4	1.9	2.6	1.9	2.8	0.7	3.0	2.9	2.0	1.7	1.9	23.5
	1860	2.3	2.1	2.3	0.5	3.3	3.3	1.5	6.3	3.3	2.5	1.5	2.5	31.4
	Mean	2.2	1.3	1.2	1.6	2.0	2.8	2.3	3.6	2.6	2.9	2.2	1.6	26.3

RAINFALL OF GREAT BRITAIN.

DETAILS OF MONTHLY FALL.

From the Quarterly Returns of the Meteorological Society of Scotland.

Period.		Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Dumfries.....		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Mn. 16 Stations	1858	4.2	1.3	2.6	2.6	5.1	2.8	4.0	5.7	5.9	7.5	2.5	5.4	49.66
150 to 2,268 feet above the Sea.	1859	7.8	5.8	6.4	4.2	0.5	2.2	2.9	3.8	6.2	4.2	4.9	5.8	54.70
Ettrick Pen Top.....	1857	6.5	7.4	3.5	3.5	3.4	5.5	5.4	4.0	7.0	6.5	5.7	12.7	67.15
	1858	4.5	6.75	in 3	mth	9.7	2.2	4.3	8.0	11.5	10.0	3.3	6.9	67.15
	1859	10.0	4.6	12.2	6.5	0.7	2.5	4.9	5.5	5.4	6.0	5.1	6.8	70.23
2,268 feet.	Mean	7.0	3.4	6.0	4.1	4.6	3.4	4.9	5.8	8.0	7.5	4.7	8.8	68.18
Wan Lockhead 1,564 feet.	1856	5.1	6.5	0.1	4.1	2.6	8.0	5.7	8.1	4.9	5.2	3.0	11.5	64.80
	1857	4.7	3.6	6.6	3.9	2.3	3.6	4.3	2.9	6.7	4.9	5.5	8.9	57.90
	1858	5.9	1.3	3.3	2.0	6.9	3.6	5.8	3.5	5.8	7.9	3.5	8.2	57.70
	1859	12.3	6.5	9.0	2.9	0.5	3.5	4.0	4.5	6.3	4.4	5.4	3.7	62.95
	1860	11.7	5.8	7.4	1.7	4.6	6.8	4.9	4.7	3.1	9.1	3.3	4.4	67.53
	Mean	7.9	4.8	5.3	2.9	3.4	5.1	4.9	4.7	5.4	6.3	4.2	7.3	62.18
Drumlanrig ... 186 feet.	1856													
	1857	4.0	3.6	4.1	2.5	2.2	2.5	2.4	2.7	3.3	3.6	3.5	5.5	39.95
	1858	4.5	2.6	1.4	3.6	5.3	3.1	4.5	4.5	4.4	6.5	2.0	5.6	48.00
	1859	7.1	7.1	5.6	3.5	0.6	2.3	3.0	2.3	4.7	4.0	4.2	4.5	48.90
	1860	9.0	3.8	5.0	0.9	2.5	5.5	1.9	6.1	1.0	6.8	3.2	4.6	50.33
	Mean	6.2	4.3	4.0	2.6	2.7	3.3	2.9	3.9	3.4	5.2	3.2	5.1	46.79
Bowhill..... 653 feet.	1857	2.6	1.5	3.4	1.1	1.8	3.6	1.2	1.4	3.4	1.2	2.3	1.8	25.35
	1858	2.2	0.9	1.8	1.0	2.9	0.7	2.8	1.9	4.8	4.9	2.1	2.3	28.34
	1859	4.3	2.8	3.1	1.9	0.2	1.7	2.0	0.9	2.1	2.2	3.4	3.8	28.44
	1860	5.8	3.0	3.3	1.1	1.3	5.7	1.4	2.4	1.1	4.1	2.5	3.5	35.23
	Mean	3.7	2.0	2.9	1.3	1.5	2.9	1.8	1.7	2.8	3.1	2.6	2.8	26.34
Stobo Castle... 600 feet.	1857	1.3	1.4	1.2	0.5	0.7	2.8	1.4	1.0	3.2	1.2	1.9	0.3	16.86
	1858	1.4	0.7	0.3	0.5	2.5	1.1	1.9	1.3	1.3	3.2	1.5	5.3	21.00
	1859	3.2	2.2	3.7	1.8	0.0	1.0	1.4	2.0	1.7	3.7	3.0	1.9	25.60
	1860	5.3	1.4	2.2	0.6	1.8	2.8	0.5	2.8	0.5	3.0	1.1	1.6	23.65
	Mean	2.8	1.4	1.8	0.8	1.3	1.9	1.3	1.8	1.7	2.8	1.9	2.3	21.78
Milne Garden 100 feet.	1856	0.7	1.3	0.1	2.2	3.6	3.0	2.6	3.0	4.7	0.3	1.1	3.2	25.80
	1857	2.5	0.4	2.7	1.2	1.7	3.4	3.4	1.8	5.3	1.1	5.6	0.3	29.40
	1858	0.6	0.7	2.2	1.2	3.3	2.9	5.1	2.0	3.0	3.3	3.7	1.9	29.90
	1859	2.0	1.6	3.1	3.9	0.0	3.5	4.9	1.2	1.4	5.6	1.6	4.0	32.80
	1860	4.7	1.2	2.1	0.9	1.9	5.6	4.5	2.0	1.6	2.4	2.8	2.1	31.80
	Mean	2.1	1.0	2.0	1.9	2.1	3.7	4.1	2.0	3.2	2.5	3.0	2.3	29.94
Thirlstane..... 558 feet.	1856	1.0	1.3	0.5	1.6	3.0	2.7	1.9	4.2	7.2	1.3	0.8	2.7	28.18
	1857	1.4	0.3	1.8	2.1	1.8	2.3	1.4	2.3	3.7	1.8	2.8	2.0	23.68
	1858	1.4	0.7	1.3	1.8	2.5	1.6	4.0	1.9	2.9	2.5	5.7	2.2	28.49
	1859	3.5	1.5	2.6	2.8	0.4	2.2	1.7	0.6	2.1	4.5	3.7	1.9	27.53
	1860	1.8	4.5	3.3	0.5	0.7	5.4	1.3	1.1	0.4	3.5	2.8	3.6	28.86
	Mean	1.8	1.7	1.8	1.9	1.7	2.8	2.1	2.0	3.2	2.7	3.2	2.5	27.35
Yester..... 420 feet.	1856	2.6	3.7	0.4	2.0	4.7	6.8	1.4	3.3	8.1	2.8	1.9	4.6	42.35
	1857	3.0	1.6	2.7	2.4	1.6	4.7	2.5	2.9	5.1	2.1	3.3	2.0	33.90
	1858	0.6	0.8	2.1	1.9	3.6	1.4	6.0	0.6	1.5	5.0	3.7	2.5	29.73
	1859	3.0	1.9	2.5	3.6	0.8	2.1	3.9	1.4	1.3	5.5	3.8	2.3	32.05
	1860	4.2	1.7	2.2	1.6	0.8	4.3	2.8	2.6	3.5	2.9	3.0	4.8	34.40
	Mean	2.7	1.9	2.0	2.3	2.3	3.9	3.3	2.2	3.9	3.7	3.1	3.2	34.50
East Linton... 90 feet.	1856	3.0	2.6	0.1	2.5	3.0	4.4	2.1	3.9	6.9	1.0	1.5	4.0	34.95
	1857	2.3	0.8	2.3	2.0	1.3	3.8	2.7	2.9	5.7	1.9	2.6	1.0	29.35
	1858	1.4	0.9	1.9	1.1	2.2	1.0	3.7	2.2	1.3	3.6	2.3	1.7	23.32
	1859	1.3	1.0	2.3	2.3	0.2	2.2	2.9	1.4	1.1	4.2	2.8	2.3	24.04
	1860	3.7	0.8	1.5	0.8	0.7	3.5	0.7	2.0	1.2	2.4	3.1	6.2	26.61
	Mean	2.3	1.2	1.6	1.7	1.5	3.0	2.4	2.5	3.3	2.6	2.5	3.0	27.65

RAINFALL OF GREAT BRITAIN.

DETAILS OF MONTHLY FALL.

From the Quarterly Returns of the Meteorological Society of Scotland.

Period.		Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Glasgow	1857	2.3	2.3	2.3	1.6	2.3	3.7	2.3	1.8	4.7	2.7	2.6	5.0	33.65
Height 200 feet above the Sea.	1858	3.7	1.3	3.0	2.7	3.8	5.6	6.8	3.0	4.2	5.9	2.2	4.1	46.20
	1859	5.3	5.3	5.2	4.4	0.6	2.0	2.5	2.9	4.9	6.1	3.2	2.4	44.76
	1860	3.0	7.7	4.1	1.2	2.2	5.7	1.8	4.5	1.2	4.6	2.2	2.3	40.47
	Mean	3.6	4.1	3.8	2.5	2.2	4.2	3.3	3.1	3.7	4.8	2.5	3.5	41.27
Greenock ...	1856	3.9	6.2	0.8	4.1	4.2	7.3	2.5	4.8	3.2	3.2	2.7	7.6	50.57
64 feet.	1857	6.2	5.9	5.2	4.7	2.5	2.5	2.3	2.0	4.5	4.5	3.6	8.7	52.62
	1858	7.6	1.4	3.0	4.8	5.3	3.6	4.7	3.2	4.1	8.2	2.1	9.9	57.90
	1859	9.1	9.0	9.9	6.6	0.4	1.1	3.3	4.1	7.3	3.8	6.1	7.8	68.50
	1860	7.9	7.0	7.2	2.0	4.0	6.0	1.5	5.6	3.4	7.3	3.3	4.3	59.50
	Mean	6.9	5.9	5.2	4.4	3.3	4.1	2.9	3.9	4.5	5.4	3.6	7.7	57.82
Thurston.....	1856	3.8	5.8	0.0	1.2	2.8	5.9	0.8	5.4	7.7	1.2	0.9	1.6	37.16
320 feet.	1857	1.3	0.9	2.1	2.4	1.1	5.2	1.8	3.7	5.3	1.9	1.7	0.8	28.20
	1858	0.4	0.4	0.9	0.9	3.2	1.2	2.2	1.5	2.5	4.5	4.5	1.8	24.00
	1859	0.9	1.0	1.8	2.7	0.1	2.4	3.5	0.8	0.2	5.2	2.3	3.0	23.90
	1860	5.0	0.1	3.3	0.6	1.7	4.1	0.4	2.5	1.4	5.2	6.6	1.9	32.78
	Mean	2.3	1.6	1.6	1.6	1.8	3.8	1.7	2.8	3.4	3.6	3.2	1.8	29.21
Millfield	1857	2.6	1.6	2.9	3.1	0.9	4.3	1.6	2.0	4.2	2.0	2.6	4.3	32.10
Near Stirling, which is taken from Mar. 1860. 169 feet.	1858	3.7	1.9	1.4	2.1	3.3	2.5	5.4	2.8	3.8	4.9	1.5	3.3	36.60
	1859	5.3	6.4	6.4	5.4	0.2	2.0	2.6	2.8	2.1	4.1	4.1	3.3	44.74
	1860	4.6	1.5	3.2	1.1	1.4	4.6	1.6	4.6	1.1	5.1	1.5	3.5	33.82
	Mean	4.0	2.8	3.5	2.9	1.5	3.4	2.8	3.1	2.8	4.0	2.4	3.6	36.81
Callton Mor	1856	2.2	4.0	0.1	2.2	2.9	6.5	4.2	3.7	2.6	3.2	2.6	6.7	40.83
65 feet.	1857	4.3	2.9	3.1	2.3	1.4	2.1	2.8	2.5	3.1	3.2	3.3	6.3	37.30
	1858	4.5	0.8	3.1	2.8	4.4	5.5	3.7	6.0	3.3	5.1	1.4	8.8	49.37
	1859	5.4	4.2	5.9	3.6	0.7	2.3	3.5	5.7	7.0	3.2	3.6	3.8	49.00
	1860	5.5	2.7	4.7	2.5	4.2	4.2	1.5	6.3	2.2	7.1	3.1	1.9	45.82
	Mean	4.4	2.9	3.4	2.7	2.7	4.1	3.1	4.8	3.6	4.4	2.8	5.5	44.46
Balfour	1857	0.9	0.6	2.4	3.3	2.6	3.3	1.1	2.5	3.4	2.0	2.6	1.3	26.09
130 feet.	1858	1.8	1.1	1.2	0.9	2.1	1.7	4.2	2.6	2.7	3.4	2.3	3.9	27.82
	1859	2.9	2.1	2.9	2.4	0.1	2.1	2.0	0.9	1.3	3.4	2.6	2.8	25.46
	1860	3.8	0.9	2.3	0.3	0.5	3.9	1.1	2.6	0.5	2.2	2.5	3.8	24.38
	Mean	2.4	1.2	2.2	1.7	1.3	2.7	2.1	2.2	2.0	2.7	2.5	2.9	25.94
Pittenween .	1857	1.5	0.7	2.6	1.9	1.6	3.1	1.0	1.5	2.8	1.4	2.0	1.2	21.31
75 feet.	1858	1.4	0.9	1.0	1.4	2.0	1.5	3.4	2.4	2.1	3.3	2.7	2.9	25.07
	1859	1.5	1.4	2.1	2.2	0.2	2.0	2.7	0.6	1.3	4.1	3.4	2.5	24.01
	1860	3.9	1.1	2.5	0.9	0.9	3.9	1.0	2.0	0.5	2.6	3.3	4.8	27.36
	Mean	2.1	1.0	2.0	1.6	1.2	2.6	2.0	1.6	1.7	2.8	2.9	2.9	24.44
Trinity Gask	1857	2.6	1.0	3.0	2.4	2.8	2.9	1.6	2.2	4.7	1.9	2.3	3.3	30.70
150 feet.	1858	2.5	0.9	1.4	2.4	3.6	1.8	5.0	1.9	3.1	4.4	1.4	4.7	33.10
	1859	4.4	2.4	3.2	3.9	0.2	2.0	2.0	1.5	2.7	4.0	2.3	2.8	31.40
	1860	4.7	1.9	2.7	0.2	1.3	4.5	2.7	3.2	0.9	3.3	4.1	4.0	33.55
	Mean	3.6	1.5	2.6	2.2	2.0	2.8	2.8	2.2	2.9	3.4	2.5	3.7	32.19
Easdale	1858	6.0	1.2	4.9	3.9	4.8	5.9	4.9	4.7	3.6	7.5	0 8	7.5	55.70
25 feet.	1859	6.8	5.0	8.0	5.5	0.5	2.9	4.6	7.5	8.1	3.3	3.8	4.4	60.40
	1860	4.9	5.7	5.7	2.5	4.7	4.4	1.8	3.0	3.0	9.3	1.6	1.8	48.40
	Mean	5.9	4.0	6.2	4.0	3.3	4.4	3.8	5.0	4.9	6.7	2.1	4.6	54.83
Tyndrum ...	1858	13.5	3.0	3.4	4.2	7.2	5.8	5.5	5.7	5.8	8.5	2.5	8.9	74.07
792 feet.	1859	17.0	15.0	16.2	...	...	...	...	...	...	...	...	...	...
	1860	8.1	7.3	8.2	2.5	4.6	6.4	3.0	6.7	5.0	15.8	3.3	3.4	74.30

RAINFALL OF GREAT BRITAIN.

DETAILS OF RAINFALL.

From the Quarterly Returns of the Meteorological Society of Scotland.

Period.		Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Perth	1856	1.8	4.1	0.2	2.2	2.6	3.7	2.0	5.1	5.7	1.4	1.0	3.8	33.49
	1857	2.3	0.9	3.8	3.2	2.4	3.5	1.6	2.2	3.8	1.9	2.6	2.2	30.50
	1858	2.2	1.0	1.2	2.0	2.3	2.0	7.0	2.7	3.0	3.8	1.9	3.6	32.73
Height 66 feet	1859	3.9	2.4	3.0	3.5	0.3	2.7	2.2	1.5	3.2	3.7	2.5	3.7	32.58
above the Sea.	1860	3.6	2.2	2.7	0.6	1.9	7.1	3.6	3.5	1.2	3.1	4.3	4.6	38.36
	Mean	2.8	2.1	2.2	2.3	1.9	3.8	3.3	3.0	3.3	2.8	2.5	3.6	33.53
Kettins	1856	3.2	4.3	0.3	3.4	2.6	3.7	2.5	4.6	7.0	1.4	1.9	3.3	38.17
	1857	2.0	0.7	4.6	3.0	2.1	2.9	2.5	2.2	4.5	2.6	2.7	1.5	31.30
	1858	1.5	1.2	1.2	1.5	2.4	1.8	6.7	3.1	2.8	3.1	2.2	3.5	31.09
	1859	4.3	2.4	2.4	2.2	0.3	3.8	3.6	1.2	3.6	2.2	3.1	2.6	31.60
228 feet.	1860	3.4	1.5	2.3	0.5	1.2	6.8	3.1	3.5	0.7	2.2	5.1	6.1	36.39
	Mean	2.9	2.0	2.2	2.1	1.7	3.8	3.7	2.9	3.7	2.3	3.0	3.4	33.71
Barry	1856	4.2	4.0	0.0	3.2	3.8	4.0	2.5	4.2	7.0	1.3	1.3	2.6	38.16
	1857	1.3	1.0	3.3	3.5	2.5	3.0	1.5	1.6	3.6	1.8	2.1	0.9	26.01
	1858	1.2	1.1	1.2	1.3	2.0	1.3	3.8	2.4	2.8	3.3	3.0	3.5	26.82
	1859	1.4	1.3	2.1	1.7	0.2	2.4	2.4	1.4	1.5	4.5	3.1	1.7	23.78
35 feet.	1860	2.0	1.0	2.2	0.4	1.1	4.4	2.6	2.7	1.5	2.4	4.7	3.8	28.89
	Mean	2.0	1.7	1.8	2.0	1.9	3.0	2.5	2.5	3.3	2.7	2.8	2.5	28.73
Arbroath	1856	3.0	2.8	0.1	3.1	2.9	3.2	2.1	3.8	5.4	1.5	2.0	2.3	32.26
	1857	2.0	1.1	2.7	3.2	2.1	2.7	0.9	1.6	2.6	1.3	2.4	1.0	23.69
	1858	0.9	1.0	1.3	1.3	2.1	1.5	3.1	2.3	2.0	2.7	1.9	4.3	24.33
	1859	1.2	1.3	2.6	2.2	0.3	2.7	2.4	1.4	1.7	4.1	3.2	2.2	25.38
75 feet.	1860	3.4	1.1	2.0	0.8	1.2	4.7	1.9	3.0	1.0	2.5	4.3	4.6	30.50
	Mean	2.1	1.5	1.7	2.1	1.7	3.0	2.1	2.4	2.6	2.4	2.7	2.9	27.23
Fetteresairn.	1856	2.8	2.5	0.1	3.7	1.4	1.4	1.4	2.2	3.8	1.0	1.1	1.9	23.31
	1857	3.4	0.2	3.9	4.0	1.6	1.8	1.2	1.1	4.6	1.2	3.1	1.4	27.50
	1858	0.9	0.9	1.6	0.8	1.3	1.3	3.8	1.8	2.3	3.0	3.1	4.2	25.00
	1859	1.8	1.8	2.4	1.7	0.3	1.5	2.1	1.8	2.3	6.2	2.4	3.2	27.49
241 feet.	1860	3.1	3.5	1.2	1.5	1.3	6.3	3.2	4.3	0.7	3.3	6.4	6.6	41.43
	Mean	2.4	1.8	1.8	2.3	1.2	2.5	2.3	2.2	2.8	3.0	3.2	3.5	28.95
Castle New..	1856	1.9	2.2	0.2	5.1	3.2	1.9	4.1	2.4	8.9	1.1	6.2	2.6	39.82
	1857	4.8	1.7	5.2	2.0	1.7	2.2	1.1	1.2	6.0	1.9	3.8	1.5	33.05
	1858	1.4	1.3	3.2	0.9	2.4	1.1	4.6	2.2	1.1	3.4	1.0	2.6	25.09
	1859	2.1	1.8	2.2	3.7	0.1	2.7	1.5	1.9	1.5	8.0	3.6	5.3	34.54
868 feet.	1860	2.7	3.9	2.6	2.0	2.4	5.7	3.1	4.7	1.1	2.5	3.4	6.4	40.49
	Mean	2.6	2.2	2.7	2.7	1.9	2.7	2.9	2.5	3.7	3.4	3.6	3.7	34.60
Elgin	1856	1.8	1.3	0.3	3.4	1.8	2.9	2.9	1.6	4.3	1.4	3.2	2.1	26.97
	1857	2.9	0.3	1.5	1.4	0.8	2.5	1.4	1.5	5.4	0.9	3.5	1.8	23.92
	1858	2.0	0.6	3.2	0.9	3.1	1.3	4.7	2.0	3.3	3.2	1.1	1.6	27.04
	1859	1.3	1.8	2.1	3.2	0.3	1.6	1.9	1.3	1.1	7.6	2.3	4.8	29.36
28 feet.	1860	1.7	1.4	2.6	1.4	1.6	2.4	2.7	3.2	2.2	2.7	1.8	2.1	25.71
	Mean	1.9	1.1	1.9	2.0	1.5	2.2	2.7	1.9	3.3	3.2	2.4	2.5	26.60
Stornoway...	1856	2.1	3.6	0.2	1.6	1.0	6.1	5.8	2.3	2.4	1.4	3.7	5.5	35.69
	1857	4.7	5.7	4.7	1.8	2.4	1.6	3.6	2.9	4.5	3.9	3.8	6.2	45.84
	1858	0.6	2.2	2.8	0.6	2.7	3.3	4.4	1.8	5.0	3.7	2.0	4.4	39.55
	1859	5.4	3.6	6.2	3.1	0.6	3.2	2.7	3.5	4.7	2.6	3.2	4.1	42.85
70 feet.	1860	2.8	2.0	5.8	2.7	4.1	2.4	1.5	5.0	3.9	8.8	2.3	2.8	44.15
	Mean	4.3	3.4	3.9	2.0	2.2	3.3	3.6	3.1	4.1	4.1	3.0	4.6	41.62
Scourie.....	1857	5.8	2.8	2.2	0.9	0.8	1.5	4.6	1.6	4.8	3.9	3.9	6.8	39.60
	1858	7.5	1.4	3.1	0.8	3.5	3.9	3.7	3.0	5.5	5.0	2.2	3.2	42.87
	1859	6.0	4.1	5.0	2.7	0.4	1.5	4.1	3.2	4.6	3.2	2.8	4.4	42.58
26 feet.	1860	2.5	3.8	5.1	1.8	2.7	2.8	2.1	4.3	4.1	6.9	1.4	1.9	39.40
	Mean	5.6	3.0	3.9	1.6	1.9	2.4	3.6	3.0	4.7	4.7	2.6	4.1	41.11

RAINFALL OF GREAT BRITAIN.

DETAILS OF MONTHLY FALL.

From the Quarterly Returns of the Meteorological Society of Scotland.

	Year.	Jan.	Feb.	Mar.	Apr.	May.	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Aberdeen, 115 feet above the Sea.	1856	2.00	1.60	0.20	3.53	2.92	3.90	2.40	5.10	7.55	2.93	6.65	5.00	43.78
	1857	3.50	1.00	3.63	3.10	1.38	2.10	1.45	2.33	3.20	1.25	3.60	0.53	27.07
	1858	1.16	0.32	2.53	0.90	1.84	1.36	3.60	2.85	1.25	4.85	3.48	4.15	28.29
	1859	0.90	1.61	1.88	3.20	0.18	1.55	3.32	2.04	3.15	7.00	3.35	2.47	30.65
	1860	4.75	2.10	2.45	1.30	1.30	3.60	1.25	3.40	1.50	2.50	4.90	5.60	34.65
	1861	1.50	1.90	2.75	1.12	1.80	2.25	2.35	4.50	4.00	1.70	4.85	2.25	30.97
	Mean	2.30	1.42	2.24	2.19	1.57	2.46	2.39	3.37	3.44	3.37	4.47	3.33	32.55
Banchory Devenick, 99 feet above the Sea.	1858	1.10	0.60	2.20	0.60	1.50	0.90	3.60	3.00	1.30	4.80	4.00	5.30	28.90
	1859	1.10	1.30	2.50	4.50	0.00	1.60	2.80	1.80	1.00	6.70	4.90	3.20	31.40
	1860	4.20	2.50	2.30	1.50	1.10	3.50	0.70	2.90	1.00	2.60	5.50	6.20	34.00
	1861	1.30	1.30	3.50	0.80	0.70	3.20	2.70	3.60	4.30	1.60	4.30	2.10	29.40
	Mean	1.92	1.45	2.60	1.85	0.83	2.30	2.46	2.82	1.90	3.92	4.68	4.20	30.93
Strachan School House, 200 feet above the Sea.	1856	2.89	3.55	0.12	5.40	1.96	2.84	2.74	2.53	6.90	1.33	2.67	2.13	35.06
	1857	1.95	1.84	4.80	3.10	2.04	2.09	1.23	1.20	6.44	1.59	4.07	1.29	31.64
	1858	0.57	1.48	2.50	1.45	1.77	1.83	4.66	3.25	1.70	2.90	3.10	4.51	29.72
	1859	2.80	1.72	2.45	2.50	0.25	2.90	2.52	1.62	2.53	5.54	4.65	1.80	31.28
	1860	3.50	2.20	2.88	1.56	1.57	4.34	2.66	5.03	0.96	1.85	5.76	5.85	38.16
	1861	1.12	2.47	2.65	1.42	2.93	2.51	2.24	5.03	4.10	2.20	2.00	2.76	31.43
	Mean	2.14	2.21	2.56	2.57	1.76	2.74	2.68	3.11	3.77	2.57	3.71	3.06	32.88
Braemar, 1110 feet above the Sea.	1856	...	...	...	3.25	2.95	2.13	2.37	1.88	6.03	1.03	1.92	1.84	
	1857	3.04	0.87	4.09	2.54	1.59	2.77	2.28	1.56	5.36	1.29	3.37	3.93	32.69
	1858	2.35	1.02	2.16	1.30	2.75	1.47	4.87	2.00	1.55	2.74	2.30	3.46	27.97
	1859	4.15	2.63	2.83	3.08	0.26	3.17	1.97	1.62	2.50	6.23	4.78	6.83	40.06
	1860	2.78	2.40	3.04	1.22	1.85	5.70	1.67	4.94	1.09	2.80	1.18	4.69	33.36
	1861	1.07	2.45	2.80	1.36	0.90	4.36	3.82	4.53	3.84	2.17	5.69	2.90	35.89
	Mean	2.68	1.87	2.98	1.90	1.47	3.49	2.93	2.92	2.87	3.05	3.47	4.36	33.99
Castle Newe, Strathdon, 868 feet above the Sea.	1849	2.40	3.20	3.20	2.10	1.31	2.73	3.85	1.84	2.48	1.37	3.60	4.87	32.95
	1850	3.74	2.35	0.94	1.61	2.10	2.35	1.73	3.03	1.82	4.25	3.48	1.52	28.92
	1851	2.72	1.10	4.76	2.71	1.12	3.40	3.96	1.95	1.73	2.91	3.55	0.66	30.57
	1852	4.52	2.28	0.20	1.26	2.14	2.36	1.26	4.21	5.23	6.21	2.96	2.76	35.39
	1853	2.60	2.40	2.85	2.23	2.31	3.12	3.72	2.67	3.41	5.16	3.72	2.50	36.69
	1854	2.37	2.86	2.36	2.52	4.70	3.13	2.34	1.82	1.31	3.37	3.80	3.70	34.28
	1855	2.13	3.14	2.32	2.12	3.02	1.94	3.15	3.11	0.52	3.43	1.72	3.61	30.21
	1856	1.87	2.21	0.22	5.11	3.19	1.92	4.10	2.35	8.91	1.13	6.24	2.56	39.82
	1857	4.80	1.72	5.19	1.98	1.65	2.18	1.05	1.24	5.99	1.94	3.84	1.47	33.05
	1858	1.42	1.30	3.20	0.90	2.35	1.07	4.63	2.10	1.08	3.38	0.99	2.61	25.09
	1859	2.07	1.84	2.29	3.72	0.03	2.71	1.50	1.93	1.47	8.00	3.64	5.34	34.54
	1860	2.67	3.92	2.57	2.01	2.43	5.69	3.06	4.74	1.06	2.53	3.42	6.39	40.49
	1861	1.17	2.19	2.58	1.87	3.05	2.92	2.66	5.10	5.44	2.83	8.04	1.20	39.05
	Mean	2.65	2.35	2.51	2.33	2.26	2.73	2.85	2.78	3.12	3.58	3.76	3.01	33.93
Dunfermline Waterworks, 230 feet above the Sea.	1853	7.	00	2.00	0.70	7.	30	4.10	5.00	7.00	4.00	1.70	4.00	42.80
	1854	6.40	2.00	2.10	2.50	3.00	4.00	3.50	1.50	1.90	2.00	4.30	4.00	37.20
	1855		4.80		1.00	2.20	2.30	3.10	2.50	0.50	3.00	1.30	1.75	22.45
	1856	6.	60	0.50	2.50	3.50	4.90	2.90	3.70	6.50	2.50	5.	80	39.40
	1857	4.	60	3.00	4.00	2.40	4.00	2.00	1.90	4.00	3.00	2.50	2.80	34.20
	1858	2.90	1.30	2.20	2.20	3.60	1.30	4.60	2.20	3.00	7.00	2.20	3.80	36.30
	1859	3.70	2.90	3.60	4.00	0.00	2.00	4.10	1.80	3.80	3.50	3.10	2.10	34.60
	Mean	3.46	2.34	2.14	2.41	2.39	3.37	3.47	2.67	3.81	3.60	2.44	3.18	35.28

RAINFALL OF GREAT BRITAIN.

DETAILS OF MONTHLY FALL.

Period.		Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Tongue	1857	4.8	1.0	4.1	0.9	0.6	0.5	3.3	1.8	3.4	3.3	2.0	4.6	30.30
	1858	5.9	1.6	3.1	3.0	2.4	2.5	6.5	3.6	2.0	6.5	3.3	2.0	42.45
	1859	6.4	3.3	5.2	3.9	0.0	1.6	3.9	2.6	3.5	8.3	1.9	6.1	46.70
Height 40 feet above the Sea.	1860	2.8	2.5	3.8	1.0	3.4	5.6	1.4	5.3	3.6	6.7	2.5	5.8	44.40
	Mean	5.0	2.1	4.1	2.2	1.6	2.6	3.8	3.3	3.1	6.2	2.4	4.6	40.96
	1856	2.3	2.4	0.3	0.3	0.9	2.4	3.4	1.4	3.2	1.0	4.6	5.2	27.41
	1857	5.4	3.0	4.1	3.7	0.9	0.6	2.8	2.7	2.8	2.8	1.9	3.5	34.24
Sandwick	1858	3.8	0.7	2.7	0.9	2.4	2.2	4.1	2.6	2.8	5.9	2.8	3.4	34.37
	1859	5.5	4.2	5.4	4.3	0.4	2.4	2.9	2.3	2.8	6.3	2.7	5.4	44.51
100 feet.	1860	3.0	1.8	3.4	1.2	2.3	3.8	2.0	4.9	4.7	5.5	3.5	5.0	41.11
	Mean	4.0	2.4	3.2	2.1	1.4	2.3	3.0	2.8	3.2	4.3	3.1	4.5	36.33
	1857	6.0	3.4	3.4	3.0	0.9	1.4	3.4	1.4	1.9	2.0	2.4	4.5	33.70
	1858	4.9	0.2	2.9	1.9	1.5	2.9	2.0	0.9	2.0	7.2	2.1	2.9	31.44
Bressay	1859	8.6	4.7	6.2	4.0	0.1	1.3	3.3	3.7	4.6	5.4	4.8	3.6	50.30
25 feet.	1860	4.7	2.3	4.7	1.1	2.6	1.5	0.9	2.0	3.7	5.6	3.4	2.8	35.30
	Mean	6.0	2.7	4.3	2.5	1.3	1.8	2.4	2.0	3.0	5.0	3.2	3.5	37.68
	1853	4.7	2.0	1.8	4.6	2.0	1.7	1.8	2.5	2.9	4.9	4.1	1.2	34.2
	1854	7.0	0.4	0.7	0.5	2.0	3.8	1.4	0.8	0.5	2.8	3.7	2.5	26.1
	1855	0.8	1.6	1.0	0.5	3.0	1.3	2.4	2.6	1.3	4.6	2.0	3.6	24.7
Fassaroe	1856	5.0	2.3	1.7	4.5	4.5	1.5	1.1	4.2	5.2	4.1	0.7	4.1	38.9
Co. Wicklow.	1857	1.0	1.2	4.7	6.6	1.4	4.0	1.3	1.8	2.4	2.7	2.6	1.7	31.4
200 feet.	1858	1.4	2.9	2.6	9.8	2.7	1.5	4.0	2.0	3.4	3.9	3.0	3.9	41.1
	1859	3.3	3.0	2.8	5.8	0.9	2.4	1.9	2.9	4.4	1.8	6.1	5.1	40.4
	1860	10.8	1.6	3.0	1.5	2.7	9.7	2.7	6.5	2.3	5.6	4.0	7.1	57.5
	Mean	4.2	1.9	2.3	4.2	2.4	3.2	2.1	3.0	2.8	3.8	3.3	3.6	36.8
	1854	2.1	1.7	1.1	0.5	1.1	2.5	1.8	1.8	1.9	4.5	2.9	2.6	24.5
	1855	0.3	1.8	3.0	0.8	1.7	2.0	3.5	2.6	0.8	4.1	2.0	2.7	25.3
	1856	2.9	2.6	0.7	1.9	2.1	2.9	3.2	4.9	2.7	3.2	2.5	5.7	35.3
Douglas	1857	2.5	2.4	2.9	4.4	1.4	2.1	1.0	1.5	1.5	3.5	2.6	1.6	27.4
Isle of Man.	1858	1.5	0.9	1.2	5.1	2.2	4.2	3.2	2.2	2.7	3.5	2.2	4.1	33.0
103 feet.	1859	2.1	3.6	2.7	3.0	0.2	1.7	1.6	1.6	2.0	3.6	4.0	2.9	29.0
	1860	6.2	1.9	3.0	2.4	2.2	5.0	1.1	4.3	1.9	5.9	2.0	2.0	37.9
	Mean	2.5	2.1	2.1	2.6	1.6	2.9	2.2	2.7	1.9	4.0	2.6	3.1	30.3

SHAW'S WATERWORKS, GREENOCK, West of Scotland.

Height above Sea.	1839	1841	1842	1843	1844	1845	1846
	in.	in.	in.	in.	in.	in.	in.
800 feet	58.40	61.70	53.20	64.80	46.20	65.50	64.65
600 ,, ...	62.20	63.90	54.60	60.40	47.25	68.55	67.10
560 ,, ...	61.50	64.20	56.10	69.90	47.85	71.65	72.50
540 ,, ...	60.20	62.70	55.60	63.20	47.05	68.45	64.45
480 ,, ...	61.15	61.80	51.70	52.80	40.65	61.15	65.05
Mean	60.69	62.86	54.24	60.82	45.80	67.26	66.75

Height above Sea.	1847	1848	1849	1850	1851	1852	Mean of 25 years.
800 feet	56.10	59.50	58.40	58.90	57.90	62.60	55.93
600 ,, ...	59.20	65.60	61.30	66.30	61.60	68.40	58.52
560 ,, ...	63.00	75.00	71.10	71.90	67.00	79.50	64.63
540 ,, ...	55.90	65.30	62.00	57.30	57.10	61.80	56.75
480 ,, ...	56.20	63.20	62.00	61.10	61.70	81.50	61.50
Mean	58.08	65.72	62.96	63.08	61.06	70.76	59.47

FORFARSHIRE, East of Scotland.

	Arbroath.	Dundee.	Stricken.	Craigton.	Hillhead.
	65 ft.	100 ft.	500 ft.	500 ft.	500 ft.
6 years ... 1853 to 1858	24.97 in.	28.9 in.	32.98 in.	32.33 in.	31.51 in.

REMARKABLE FALLS OF RAIN

IN ONE DAY, AND IN A SHORT SPACE OF TIME,

During the Year 1852.

FALLS IN ONE DAY.

DATE.	PLACE.	Depth fallen.	DATE.	PLACE.	Depth fallen.
		Inches.			Inches.
May 18th	Truro	2.3	Oct. 4th	Uckfield	2.1
June 9th	St. John's Wood	1.5	,, 5th	Jersey	1.7
,, ,,	Feilde's Weir	1.0	,, ,,	Newport	2.3
,, ,,	Oxford	1.7	,, ,,	Worthing	1.6
,, 21st	North Shields	1.9	,, ,,	Feilde's Weir	2.6
July 5th	,, ,,	2.6	,, 25th	Worthing	2.4
,, ,,	Durham	2.3	,, ,,	Uckfield	1.8
,, 6th	Derby	1.7	,, 26th	Midhurst	1.5
,, 12th	Guernsey	1.7	,, ,,	Leeds	2.0
,, ,,	Wakefield	1.9	Nov. 2nd	Feilde's Weir	1.8
,, 25th	Feilde's Weir	1.2	,, 10th	Nottingham	1.7
,, 26th	Nottingham	2.1	,, 11th	Bedford	1.5
Aug. 11th	North Shields	3.1	,, 12th	Feilde's Weir	1.2
,, 17th	Stone	1.6	,, 13th	North Shields	1.6
,, 24th	North Shields	1.5	,, 15th	Feilde's Weir	1.5
,, 28th	,, ,,	3.9	,, 16th	North Shields	1.6
,, ,,	Feilde's Weir	1.2	Dec. 4th	Stonyhurst	1.8
,, 29th	Durham	2.5	,, 17th	Uckfield	1.0
Oct. 4th	Guernsey	1.8	,, ,,	Leeds	1.3
,, ,,	North Shields	2.4			

FALLS IN A SHORT TIME.

DATE.	PLACE.	Depth fallen.	Time falling.	DATE.	PLACE.	Depth fallen.	Time falling.
		In.	H. M.			In.	H. M.
June 14th	Nottingham	0.3	0 9	Aug. 17th	Linslade	0.9	1 0
,, 26th	Dunino	0.5	0 20	,, ,,	Hartwell Rec.	1.4	5 0
July 5th	Grantham	1.6	1 0	,, ,,	Grantham	0.8	0 40
,, ,,	Gainsborough	0.1	1 0	,, ,,	Hawarden	1.7	1 0
,, ,,	North Shields	2.6	5 30	,, 18th	Stone	0.6	4 0
,, 16th	Ryde	0.8	0 20	Sept. 5th	Grantham	0.5	0 15
,, 17th	Aylesbury	1.4	2 0	5th & 6th	Nottingham	2.6	28 0
,, ,,	Whitehaven	1.3	1 0	,, 6th	Linslade	0.7	2 0
,, 25th	Greenwich	0.5	0 15	,, 8th	Aylesbury	0.8	1 0
,, ,,	,,	1.0	0 15	,, 10th	Southampton.	0.7	1 0
Aug. 10th	Grantham	0.3	0 10	Oct. 4th	Greenwich	1.0	12 0
,, 11th	North Shields	3.1	19 30	,, 25th	Lewisham	0.5	2 0
,, 14th	Southampton.	1.7	5 0	,, 26th	Grantham	0.5	6 0

The fall of Rain at North Shields from the 26th to the 29th September was 6.4 inches, viz.: 26th, 0.7; 27th, 0.9; 28th, 3.9; 29th, 0.9.

DISTRIBUTION OF RAIN AT GREENWICH.

Table of the quantity collected at Greenwich from 1837 to 1858, in Falls of half an inch or above, in 24 hours.

Years	1837	1838	1839	1840	1841	1842	1843	1844	1845	1846	1847
Falls of .5, collected in inches	5.82	7.71	6.21	.60	8.58	4.97	6.11	6.87	5.36	8.41	1.48
Year's rain, in inches.	21.0	23.8	29.6	18.2	33.3	22.6	24.6	24.9	22.4	25.3	17.8

Years	1848	1849	1850	1851	1852	1853	1854	1855	1856	1857	1858
Falls of .5, collected in inches	6.31	8.28	4.03	7.08	14.21	10.93	4.96	6.48	5.62	9.20	5.03
Year's rain, in inches.	30.2	23.9	19.7	20.5	34.4	29.0	18.7	21.1	21.8	21.4	17.20

Of the above 21 years there were 189 falls above .5 inch, distributed as follows:—

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct.	Nov	Dec	Tot.
Mean depth fallen above .5 inches....	.81	.60	.73	.80	.65	.77	.88	.85	.77	.82	.67	.60	
Number of days it fell.....	8	6	6	10	17	17	26	28	23	25	20	3	189
Number of days less than 1 inch fell.....	6	6	5	10	16	14	20	22	18	20	18	3	158
Number of days more than 1 inch fell....	2	...	1	...	1	3	6	6	5	5	2	...	31
Number of days more than 2 inches fell...	...	...	...	...	...	...	2	1	...	1	...	...	4

These Falls were distributed over the last 13 years as follows:—

1846.	Ins.
Feb. 2 ...	.70
April 5 ...	.52
,, 24 ...	.59
,, 26 ...	.58
Aug. 2 ...	.95
,, 3 ...	.54
,, 5 ...	.85
,, 6 ...	.54
Sep. 24 ...	1.18
Oct. 3 ...	.51
,, 15 ...	.95
Nov. 25 ...	.50
Mean ...	.70

1847.	
Aug. 6 ...	.98
,, 16 ...	.50
Mean ...	.72

1848.	
April 21 ...	.50
Mar. 11 ...	.50
,, 13 ...	.84
,, 24 ...	.50
Aug. 15 ...	.66
,, 31 ...	.85
Sep. 28 ...	.75
Oct. 20 ...	.51
Nov. 27 ...	.48
Dec. 16 ...	.72
Mean ...	.63

1849.	
Feb. 28 ...	.78
April 19 ...	.70
May 20 ...	.90
,, 28 ...	1.15
July 24 ...	.75
,, 25 ...	.55
,, 26 ...	.57
Sept. 1 ...	.52
,, 30 ...	.56
Oct. 4 ...	.75
Nov. 30 ...	.57
Dec. 3 ...	.48
Mean ...	.69

1850.	
May 6 ...	.65
July 4 ...	.60
Aug. 12 ...	.80
,, 21 ...	.60
Oct. 23 ...	.74
Nov. 24 ...	.64
Mean ...	.67

1851.	
Mar. 15 ...	1.45
April 20 ...	.70
,, 22 ...	.55
July 2 ...	.69
,, 23 ...	1.44
,, 24 ...	.54
Aug. 17 ...	1.71
Mean ...	1.01

1852.	
Jan. 13 ...	.91
May 26 ...	.56
June 9 ...	1.36
,, 10 ...	.99
,, 19 ...	.52
July 25 ...	1.99
Aug. 12 ...	.55
,, 15 ...	.90
,, 19 ...	.50
Sept. 8 ...	.97
,, 18 ...	.70
,, 28 ...	.94
Oct. 4 ...	.75
,, 25 ...	.92
Nov. 12 ...	.80
,, 26 ...	.85
Mean ...	.89

1853.	
Mar. 14 ...	.50
April 22 ...	.50
,, 25 ...	.80
May 3 ...	.50
June 13 ...	1.15
July 8 ...	.63
,, 14 ...	2.63
,, 28 ...	1.11
Aug. 23 ...	.89
Oct. 12 ...	.58
,, 19 ...	.59
,, 27 ...	1.05
Mean ...	.91

1854.	
Jan. 7 ...	1.18
May 8 ...	.76
,, 9 ...	.52
,, 29 ...	.50
Aug. 1 ...	.66
,, 2 ...	1.34
Mean ...	.82

1855.	
May 31 ...	.55
July 11 ...	1.42
,, 16 ...	.60
,, 26 ...	1.15
Oct. 29 ...	.60
,, 30 ...	1.06
,, 31 ...	.60
Nov. 3 ...	.50
Mean ...	.81

1856.	
Jan. 9 ...	.69
Mar. 17 ...	.85
May 13 ...	.63
,, 22 ...	.65
,, 29 ...	.59
June 20 ...	.90
Aug. 17 ...	.67
Sep. 27 ...	.64
Mean ...	.70

1857.	
Jan. 10 ...	.69
June 20 ...	.85
July 28 ...	.60
Aug. 6 ...	.52
,, 14 ...	1.12
Sep. 8 ...	1.00
,, 11 ...	1.16
Oct. 22 ...	2.75
Nov. 24 ...	.50
Mean ...	1.02

1858.	
Feb. 14 ...	.81
April 8 ...	.59
,, 29 ...	.60
June 5 ...	1.16
July 10 ...	.57
,, 16 ...	.61
Aug. 14 ...	.69
Mean ...	.72

Mean of 13 years gives 8.84 days with a fall of .79 inch.

GREAT BRITAIN.—DETAILS OF RAINFALL FOR THE WET YEAR 1852.

DEPTH FALLEN.

	January.	February.	March.	Total.	April.	May.	June.	Total.	July.	August.	September.	Total.	October.	November.	December.	Total.	Total, Year.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Jersey	4.8	1.5	1.1	7.4	1.3	2.9	4.0	8.2	2.1	3.1	4.1	9.3	8.2	5.2	5.1	18.5	43.4
Guernsey	5.4	1.0	1.0	7.4	0.8	2.7	3.6	7.1	3.5	3.4	5.4	12.3	7.5	8.4	6.4	22.3	49.1
Helstone	6.5	1.5	1.7	9.7	1.8	2.7	3.3	7.8	0.5	4.7	3.8	9.0	6.6	8.2	4.1	18.9	45.4
Falmouth	7.2	1.5	1.3	10.0	1.8	3.7	3.6	9.1	0.9	4.5	4.0	9.4	6.7	10.2	4.7	21.6	50.1
Truro	7.8	1.1	1.7	10.6	1.7	3.9	4.2	9.8	0.8	4.6	4.1	9.5	6.7	10.5	5.4	22.6	52.5
Torquay	4.7	1.1	1.4	7.2	1.3	2.5	6.5	10.3	1.0	3.6	5.1	9.7	5.7	10.6	6.7	23.0	50.2
Ventnor	3.7	0.8	0.5	5.0	0.8	2.5	4.3	7.6	1.7	3.3	7.2	12.2	6.0	7.4	3.8	17.2	43.0
Ryde	5.4	1.0	0.7	7.1	0.4	2.6	5.8	8.8	2.5	5.7	4.7	12.9	7.9	7.48	4.7	20.0	48.8
Chichester	4.2	0.8	0.4	5.4	0.6	2.1	5.0	7.7	1.0	3.7	5.7	9.8	5.7	6.4	4.0	16.1	39.0
Southampton	5.9	1.3	0.7	7.9	0.6	2.7	5.4	8.7	2.2	4.3	4.8	12.3	6.5	10.0	4.3	20.8	49.7
Abingdon	5.0	1.0	0.4	6.4	0.5	1.7	5.6	7.8	3.2	4.1	3.5	10.8	3.0	5.9	2.8	11.7	36.7
R. Observatory	3.6	0.9	0.2	4.7	0.5	1.9	4.6	7.0	2.3	4.5	3.9	10.7	3.8	6.0	2.2	12.0	34.4
St.John'sWood	3.5	1.0	0.3	4.8	0.8	1.3	5.7	7.8	2.5	3.7	3.6	9.8	3.9	6.7	2.1	12.7	35.1
Feilde's Weir	4.6	1.5	0.3	6.4	1.1	1.8	3.2	6.1	2.7	3.7	4.0	10.4	6.0	7.8	2.3	16.1	39.0
Rose Hill	4.9	1.0	0.6	6.5	0.6	2.0	6.8	9.4	3.3	3.8	3.0	10.1	2.7	6.5	2.8	12.0	38.0
Oxford	5.3	1.0	0.6	6.9	0.6	2.1	7.1	9.8	2.8	4.5	3.1	10.4	2.7	7.1	3.5	13.3	40.4
Stone	4.4	0.9	0.4	5.7	0.6	1.7	4.6	6.9	1.4	5.8	3.0	10.2	3.0	5.8	2.7	11.5	34.3
Linslade	4.8	1.4	0.4	6.6	0.6	1.6	4.3	6.5	2.4	5.4	3.0	10.8	2.8	5.0	2.7	10.5	34.4
Royston	4.5	1.2	0.4	6.1	0.4	2.3	3.3	6.0	3.3	4.1	2.7	10.1	3.6	5.2	2.1	10.9	33.1
Cardington	3.3	0.9	0.6	4.8	0.4	2.5	3.5	6.4	2.7	4.9	2.2	9.8	2.6	5.2	2.1	9.9	30.9
Bedford	3.5	1.2	0.5	5.2	0.3	2.3	3.3	5.9	2.9	6.0	2.7	11.6	2.4	5.4	2.2	10.0	32.7
Norwich	3.4	3.3	0.6	7.3	0.4	1.4	2.8	4.6	0.8	3.5	5.2	9.5	3.9	5.2	2.0	11.1	32.5
Grantham	3.0	1.2	0.5	4.7	0.2	0.9	3.8	4.9	3.2	4.8	4.7	12.7	3.2	5.4	1.3	9.9	32.2
Derby	3.5	2.4	0.6	6.5	0.2	0.7	4.0	4.9	3.9	3.4	3.3	10.6	2.8	6.6	2.3	11.7	33.7
Holkham	2.7	2.6	0.5	5.8	0.4	1.6	3.2	5.2	1.5	3.2	4.7	9.4	3.3	4.7	1.9	9.9	30.3
Nottingham	3.7	1.9	0.7	6.3	0.6	1.3	4.9	6.8	3.0	3.4	5.6	12.0	3.0	7.2	2.1	12.3	37.4
Hawarden	3.7	2.9	1.0	7.6	0.4	2.4	4.4	7.2	2.9	4.2	5.3	12.4	3.5	5.9	3.8	13.2	40.2
Gainsborough	2.7	0.8	0.5	4.0	0.2	0.8	3.5	4.5	1.7	3.1	3.5	8.3	2.3	4.8	1.6	8.7	25.5
Liverpool	2.8	2.7	0.4	5.9	0.2	1.4	2.6	4.2	3.1	4.5	1.8	9.4	3.7	4.6	3.4	11.7	31.2
Manchester *	4.7	3.9	0.5	9.1	0.5	1.4	4.7	6.6	2.6	5.4	2.4	10.4	2.7	4.5	4.9	12.1	39.0
Wakefield	3.1	1.4	2.0	6.5	0.1	0.8	5.1	6.0	3.8	2.0	3.8	9.6	2.7	5.9	2.8	11.4	33.5
Leeds	3.2	1.0	0.4	4.6	0.1	0.8	3.5	4.4	2.3	1.7	3.4	7.4	3.7	5.2	3.1	12.0	28.4
Stonyhurst	8.5	8.1	0.4	17.0	0.4	2.8	3.8	6.0	3.7	5.7	4.6	14.0	6.1	6.6	8.6	21.3	58.3
York	2.4	0.7	0.5	3.6	0.3	0.9	3.5	4.7	1.8	2.5	4.3	8.6	3.8	4.2	2.4	10.4	27.3
Whitehaven	8.0	3.5	0.3	11.8	1.2	4.2	3.5	8.9	2.9	5.2	2.1	10.2	3.0	5.1	11.0	19.1	50.0
Durham	1.6	0.6	0.4	2.6	0.7	1.9	3.4	5.0	3.4	4.1	5.2	12.7	3.0	3.9	3.4	10.3	30.6
North Shields	1.8	0.9	0.6	3.3	1.0	1.6	7.5	10.1	5.7	6.9	8.6	21.2	7.8	9.9	5.9	23.6	58.2
Glasgow	6.5	3.9	0.7	11.1	0.4	2.7	3.1	6.2	5.6	4.8	1.1	11.5	1.8	5.3	9.6	16.7	45.5
Dunino	4.8	1.7	0.9	7.4	0.4	1.5	3.0	4.9	1.5	2.2	1.6	5.3	3.6	5.1	5.0	13.7	31.3

NOTE.—Manchester Observations not taken by Mr. Vernon in August, but the Rainfall has been obtained from other sources.

GREAT BRITAIN.—DETAILS OF RAINFALL FOR THE WET YEAR 1852.

NUMBER OF DAYS' RAIN.

	January.	February.	March.	Total.	April.	May.	June.	Total.	July.	August.	September.	Total.	October.	November.	December.	Total.	Total, Year.
Jersey	21	14	5	40	7	15	17	39	6	13	16	35	18	21	21	60	174
Guernsey	25	10	4	39	7	13	17	37	6	10	14	30	18	24	25	67	173
Helstone	27	14	7	48	6	14	16	36	8	17	10	35	17	24	23	67	183
Falmouth	23	15	6	44	7	13	18	38	7	16	14	37	18	28	26	72	184
Truro	24	13	7	44	6	16	18	40	8	19	13	40	17	26	24	67	161
Torquay	19	8	5	32	4	12	22	38	12	15	12	39	15	26	25	66	175
Ventnor	22	12	2	36	5	15	22	42	5	16	16	37	18	27	22	67	182
Ryde	22	10	2	34	2	11	19	32	3	16	15	34	18	28	25	71	171
Chichester																	
Southampton	24	11	2	37	3	13	20	36	5	15	15	35	15	23	19	57	165
Abingdon																	
R. Observatory	16	10	3	29	2	12	21	35	4	15	13	32	15	22	19	56	155
St. John's Wood	20	14	5	39	5	8	25	38	6	13	16	35	15	24	17	56	168
Feilde's Weir	9	6	1	16	2	7	16	25	5	13	7	25	14	13	9	36	102
Rose Hill	17	15	3	35	3	12	24	39	8	17	14	39	13	26	21	60	173
Oxford	22	14	4	40	3	13	24	40	7	20	13	40	15	22	21	58	178
Stone	14	13	4	31	4	11	24	39	9	18	17	44	18	28	22	68	182
Linslade	19	14	6	39	5	13	23	41	10	17	15	42	14	23	19	56	168
Royston					6	21	26	53	9	24	27	60	21	29	29	79	
Cardington	16	12	3	31	4	7	25	36	7	20	11	38	16	22	18	56	161
Bedford	21	14	5	40	3	15	25	43	7	22	16	45	17	23	17	57	185
Norwich	16	17	11	44	5	10	20	35	3	15	14	32	14	21	16	51	162
Grantham	20	14	6	40	4	8	23	35	7	15	16	38	16	25	22	63	180
Derby	21	14	5	40	3	11	23	37	8	20	16	44	16	23	23	62	183
Holkham	18	18	8	44	3	12	25	40	4	16	13	33	15	23	18	56	173
Nottingham	23	18	6	47	4	13	25	42	8	23	14	45	17	24	26	67	201
Hawarden	19	10	4	33	4	14	27	45	10	12	17	39	16	27	26	69	186
Gainsborough	18	12	8	38	4	12	26	42	9	15	15	39	16	21	19	56	175
Liverpool	21	14	5	40	2	7	19	28	10	17	11	38	17	23	24	64	170
Manchester *	22	16	5	43	3	8	25	36	10	17	15	42	17	24	28	69	190
Wakefield	25	17	10	52	6	15	28	49	11	19	16	46	16	23	27	66	213
Leeds	21	14	6	41	5	10	26	41	11	19	16	46	18	23	26	67	195
Stonyhurst	21	15	3	39	4	11	24	39	14	18	17	49	18	23	26	67	194
York	14	7	4	25	4	10	21	35	7	16	14	37	15	24	21	60	157
Whitehaven	23	16	5	44	4	12	19	35	15	19	10	44	16	20	30	66	189
Durham	14	15	8	37	5	15	28	48	5	17	13	35	15	20	15	60	180
North Shields	18	23	16	57	9	16	27	52	13	23	17	53	17	26	27	70	232
Glasgow	24	16	8	48	5	10	21	36	15	18	12	45	13	20	26	59	188
Dunino	15	9	3	27	4	8	16	28	8	10	8	26	13	15	24	52	133

NOTE.—Manchester Observations not taken by Mr. Vernon in August, but the Rainfall has been obtained from other sources.

GREAT BRITAIN.—DETAILS OF RAINFALL FOR THE WET YEAR 1860.

DEPTH FALLEN.

	Jan.	Feb.	Mar.	Total.	April.	May.	June.	Total.	July.	Aug.	Sept.	Total.	Oct.	Nov.	Dec.	Total.	Total. Year.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Guernsey	6.6	2.1	2.2	10.9	2.5	4.0	5.0	11.5	1.7	6.0	3.8	11.5	3.3	4.2	6.6	14.1	48.0
Helstone	6.0	1.7	2.5	10.2	1.2	3.7	4.9	9.8	1.9	4.4	2.8	9.1	2.7	4.2	7.0	13.9	43.0
Truro	6.9	1.7	2.8	11.4	1.3	4.0	7.4	12.7	1.6	5.8	3.9	11.3	3.1	4.3	7.9	15.3	50.7
Exeter	5.1	1.4	3.5	10.0	1.2	4.6	8.0	13.8	1.9	2.3	1.8	6.0	1.6	4.7	6.1	12.4	42.2
Ventnor	3.7	0.9	3.0	7.6	1.9	3.5	4.8	10.2	2.1	3.1	4.0	9.2	2.4	3.1	3.7	9.2	36.2
Osborne	4.1	0.8	2.2	7.1	1.6	3.3	5.4	10.3	2.4	2.6	4.1	9.1	2.3	3.5	3.2	9.0	35.5
Worthing	4.6	0.7	1.8	7.1	1.8	3.5	5.0	10.3	1.8	3.7	3.0	8.5	2.5	2.8	3.3	8.6	34.5
Fairlight	3.1	0.9	1.7	5.7	2.0	3.2	3.5	8.7	2.2	2.3	4.3	8.8	1.9	2.3	2.3	6.5	29.7
Little Bridy	5.4	1.0	3.3	10.3	3.0	4.4	7.5	14.9	2.6	5.3	3.7	11.6	2.0	3.9	6.1	12.0	48.8
Barnstaple	5.3	1.5	4.0	10.8	2.8	3.4	7.0	13.2	3.6	7.9	3.5	15.0	4.0	2.6	4.4	11.0	50.0
Aldershot	3.2	0.7	2.1	6 0	1.6	2.3	5.5	9.4	1.8	4.8	3.4	10.0	1.8	3.1	3.1	8.0	33.4
Clifton	4.9	0.9	2.9	8.7	1.7	3.5	7.1	12.3	1.9	5.7	2.4	10.0	3.0	2.8	3.8	9.6	40.6
R. Observatory	1.8	1.1	1.9	4.8	1.0	3.9	5.8	10.7	2.8	3.7	3.1	9.6	1.6	2.5	2.4	6.5	31.6
Feilde's Weir	3.4	1.5	2.6	7.5	1.3	4.3	5.6	11.2	2.0	4.0	2.7	8.7	1.7	2.6	2.0	6.3	33.7
Oxford	3.3	1.3	1.9	6.5	0 0	2.8	5.1	8.5	2.4	3.8	2.5	8.7	1.6	3.2	2.6	7.4	31.1
Hartwell House	2.9	0.8	1.9	5.6	1.2	4.1	4.9	10.2	1.2	4.7	3.6	9.5	1.9	2.5	2.6	7.0	32.3
Royston	2.6	1.1	2.2	5.9	1.4	3.4	4.4	9.2	1.4	3.8	3.0	8.2	1.2	2.4	2.5	6.1	29.4
Gloucester	3.1	0.4	2.0	5.5	1.0	2.9	5.3	9.2	0.9	4.0	2.5	7.4	1.7	2.0	2.3	6.0	28.1
Cardington	2.5	1.2	1.4	5.1	0.7	3.3	4.2	8.2	1.3	2.8	2.8	6.9	1.4	2.0	1.7	5.1	25.3
Aspley	3.3	1.3	2.1	6.7	1.1	3.9	5.1	10.1	1.1	3.5	4.0	8.6	1.5	2.5	2.0	6.0	31.4
Lampeter	6.6	2.0	5.3	13.9	2.5	2.7	7.5	12.7	4.0	8.6	3.4	16.0	4.6	3.3	4.8	12.7	55.3
Norwich	2.8	1.6	2.9	7.3	1.4	3.6	4.5	9.5	2.4	3.5	3.4	9.3	1.8	3.3	2.0	7.1	33.2
Belvoir Castle	2.9	1.1	1.7	5.7	0.6	2.4	3.7	6.7	1.6	5.6	3.5	10.7	2.1	1.9	2.0	6.0	29.1
Derby	3.0	0.8	2.1	5.9	0.8	3.7	5.2	9.7	1.9	6.2	2.5	10.6	2.5	1.5	2.5	6.5	32.7
Holkham	3.1	1.7	2.3	7.1	1.0	3.8	4.3	9.1	2.0	3.3	3.1	8.4	2.6	3.0	3.3	8.9	33.5
Nottingham	2.3	2.1	2.3	6.7	0.5	3.3	3.3	7.1	1.5	6.3	3.3	11.1	...	...	...	...	...
Hawarden	2.4	0.5	2.5	5.4	0.9	1.9	4.2	7.0	1.3	5.0	1.4	7.7	2.0	2.0	3.7	7.7	27.8
Liverpool	2.1	0.7	2.2	5.0	0.9	1.8	3.5	6.2	1.5	6.0	1.7	9.2	2.4	1.0	2.9	6.3	26.7
Wakefield	3.5	0.9	2.1	6.5	0.7	3.0	4.8	8.5	3.5	4.1	2.3	9.9	1.7	3.3	3.7	8.7	31.6
Leeds	2.9	0.5	1.4	4.8	0.7	2.8	4.4	7.9	2.0	4.0	2.3	8.9	1.5	3.2	1.9	6.6	28.2
Stonyhurst	2.7	1.8	6.1	10.6	1.7	4.2	6.4	12.3	3.6	5.4	3.5	13.5	7.7	2.8	3.5	14.0	50.4
Ben Rhydding	3.7	0.7	3.0	7.4	1.3	3.5	5.9	10.7	2.4	1.9	2.0	6.3	3.2	3.3	3.4	9.9	34.3
Scarborough	1.4	1.1	1.5	4.0	0.3	2.8	1.8	4.9	2.0	2.2	3.7	7.9	1.9	3.7	2.9	8.5	25.3
North Shields	3.1	2.0	2.5	10.8	1.6	3.2	3.0	7.8	2.9	3.5	1.6	8.0	2.2	3.4	5.0	10.6	37.2
Rywell	4.6	2.2	2.9	9.7	1.6	2.4	4.6	8.6	3.5	3.0	1.5	8.0	3.5	3.3	5.0	11.8	38.1
Alnwick	4.5	1.8	2.1	8.4	1.2	2.1	3.1	6.4	2.7	3.0	1.7	7.4	2.9	5.7	5.9	14.5	36.7
South Cairn	8.1	2.2	3.9	14.2	1.7	3.3	5.6	10.6	1.1	4.3	1.8	7.2	4.6	2.9	3.7	11.2	43.2
Cargen	6.9	2.3	3.7	12.9	1.2	2.0	5.4	8.6	2.4	4.9	1.3	8.6	6.6	2.4	4.5	13.5	43.6
Bowhill	5.9	3.0	3.3	12.2	1.1	1.3	5.7	8.1	1.3	2.4	1.1	4.8	4.1	2.5	3.5	10.1	35.2
Milne Graden	4.7	1.2	2.1	8.0	0.9	1.9	5.6	8.4	1.5	2.0	1.6	8.1	2.4	2.8	2.1	7.3	31.8
Yester	4.2	1.7	2.2	8.1	1.6	0.8	4.3	6.7	2.8	2.6	3.6	9.0	2.9	3.0	4.8	10.7	34.5
Thurston	5.0	0.1	3.3	8.4	0.6	1.7	4.1	6.4	0.4	2.5	1.4	4.3	5.2	0.6	1.9	13.7	32.8
East Linton	3.7	0.8	1.5	6.0	0.8	0.7	3.4	4.9	0.7	2.0	1.2	3.9	2.4	3.1	6.2	11.7	26.5
Sneaton	2.9	0.7	1.2	4.8	0.6	0.7	3.4	4.7	0.4	1.6	0.9	2.9	2.4	2.5	4.4	9.3	21.7
Tyndrum	8.1	7.3	8.2	23.6	2.5	4.6	6.4	13.5	3.0	6.7	5.0	14.7	15.8	3.3	3.4	22.5	74.3
Baillieston	4.2	2.2	2.8	9.7	1.4	2.3	4.2	7.9	1.6	3.6	1.2	6.4	4.8	1.8	2.5	9.1	33.1
Glasgow	3.0	7.7	4.1	14.8	1.2	2.2	5.7	9.1	1.8	4.5	1.2	7.5	4.6	2.2	2.3	9.1	40.5
Greenock	7.9	7.0	7.9	22.1	2.1	3.9	5.8	11.8	1.5	5.6	3.5	10.6	7.3	3.3	4.2	14.8	59.3
Oban	4.9	4.6	6.2	15.7	2.6	5.5	5.6	13.7	2.2	4.4	4.0	10.6	11.1	1.8	1.9	14.8	54.8
Easdale	4.9	5.7	5.7	16.3	2.5	4.7	4.4	11.6	1.8	3.0	3.0	7.8	9.3	1.6	1.8	12.7	48.4
Calton Mör	5.5	2.7	4.7	12.9	2.5	4.2	4.2	10.9	1.5	6.3	2.2	10.0	7.2	3.1	1.8	12.1	45.9
Stirling	4.6	2.1	3.3	10.0	1.1	1.4	4.7	7.2	1.6	4.6	1.1	7.3	5.1	1.6	3.5	10.2	34.7
Balfour	3.8	0.9	2.3	7.0	0.3	0.5	3.9	4.7	1.1	2.6	0.5	4.2	2.2	2.5	3.8	8.5	24.4
Nookton	4.1	1.1	2.3	7.5	0.9	0.7	4.6	6.2	1.2	2.6	0.9	4.7	3.1	4.2	4.9	12.2	30.6
Arbroath	3.4	1.0	2.0	6.4	0.8	1.2	4.7	6.7	1.9	3.0	1.0	5.9	2.5	4.3	4.7	11.5	30.5
Montrose	2.3	0.8	1.6	4.7	0.6	1.1	3.3	5.0	1.3	4.8	0.8	6.9	1.7	3.8	4.2	9.7	26.3
Banchory	4.2	2.5	2.3	9.0	1.5	1.1	3.5	6.1	0.7	2.9	1.0	4.6	2.6	5.5	6.2	14.3	34.0
Aberdeen	4.7	2.1	2.5	9.3	1.3	1.3	3.0	6.2	1.3	3.4	1.5	6.2	2.5	4.9	5.6	13.0	34.7
Elgin	1.7	1.3	2.7	5.7	1.4	1.6	2.4	5.4	2.7	3.2	2.2	8.1	2.7	1.8	2.1	6.6	25.8
Dunrobin	1.9	2.7	3.0	7.6	1.3	1.9	3.5	6.7	1.9	3.8	1.3	7.0	4.0	2.3	1.8	8.1	29.4
Harris	2.5	2.1	4.9	9.5	1.6	3.5	1.9	7.0	1.7	3.2	2.5	7.4	4.1	1.7	2.1	7.9	31.8

GREAT BRITAIN.—DETAILS OF RAINFALL FOR THE WET YEAR 1860.

NUMBER OF DAYS' RAIN.

	Jan.	Feb.	Mar.	Total.	April.	May.	June.	Total.	July.	Aug.	Sept.	Total.	Oct.	Nov.	Dec.	Total.	Total Year.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	
Guernsey	22	13	19	54	12	17	21	50	8	24	13	45	14	14	23	51	200
Helstone	28	13	20	61	13	18	23	54	11	16	12	39	18	17	17	52	206
Truro	26	17	25	68	17	18	27	62	8	21	14	43	18	15	19	52	225
Exeter	28	12	23	63	16	19	28	63	12	25	18	55	16	15	15	46	227
Ventnor	15	8	18	41	13	16	21	50	10	21	18	49	14	14	15	43	183
Osborne	14	2	15	31	11	13	18	42	9	22	15	46	8	11	10	29	148
Worthing	19	7	20	46	11	13	21	45	9	20	17	46	11	13	12	36	173
Fairlight	15	7	12	34	8	11	16	35	8	16	17	41	13	14	16	41	151
Little Bridy	25	14	29	68	18	15	26	59	14	25	20	59	17	17	17	51	237
Barnstaple	25	13	22	60	14	18	28	60	12	24	13	49	20	13	18	51	220
Aldershot	17	8	19	44	10	16	25	51	13	23	13	49	12	13	14	39	183
Clifton	26	11	18	55	16	17	28	61	16	23	13	52	16	17	20	53	221
R. Observatory	21	13	18	52	13	14	23	50	10	25	17	52	10	11	17	38	192
Feilde's Weir	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Oxford	19	7	18	44	10	15	26	51	10	19	12	41	18	15	13	46	182
Hartwell House	13	4	11	28	9	12	13	34	5	14	...	...	9	8	5	22	...
Royston	28	22	29	79	19	19	27	65	18	30	19	67	19	21	23	63	274
Gloucester	26	5	21	52	10	15	28	53	9	26	12	47	12	15	14	41	193
Cardington	17	14	19	50	16	15	26	57	12	25	13	50	12	10	17	39	196
Arpley	17	13	17	47	12	17	24	53	9	23	13	45	14	13	18	45	190
Lampeter	18	13	25	56	10	18	29	57	11	30	13	54	22	13	13	48	215
Norwich	14	11	14	39	11	12	20	43	7	14	13	34	11	10	14	35	151
Belvoir Castle	16	13	19	48	10	13	21	44	8	21	16	45	16	11	17	51	188
Derby	19	12	22	53	...	...	...	...	11	29	14	54	21	16	15	52	...
Holkham	18	15	19	52	13	15	21	49	10	17	14	41	11	14	19	44	186
Nottingham	21	17	23	61	13	17	25	55	13	31	14	58	...	...	...	61	235
Hawarden	12	2	10	24	7	12	21	40	15	22	16	53	13	11	10	34	151
Liverpool	21	9	15	45	9	15	20	44	10	23	13	46	18	13	15	46	181
Wakefield	21	14	25	60	17	18	24	59	13	24	19	56	24	23	21	68	243
Leeds	18	12	17	47	17	19	25	61	14	27	18	59	20	20	13	53	220
Stonyhurst	25	16	26	67	13	21	26	60	14	29	18	61	29	18	17	64	252
Ben Rhydding	16	6	17	39	9	15	25	49	11	26	19	56	17	16	10	43	187
Scarborough	6	11	9	26	2	9	8	19	10	18	9	37	9	14	13	36	118
North Shields	20	17	19	56	19	19	21	59	18	19	12	49	22	24	28	74	238
Bywell	22	21	24	67	20	15	25	60	15	25	19	59	22	26	25	73	259
Alnwick	13	8	14	35	8	12	16	36	11	23	11	45	20	24	26	70	186
South Cairn	18	8	20	46	8	11	17	36	5	12	8	25	19	9	15	43	150
Cargen	17	12	17	46	7	13	17	37	9	13	7	29	21	7	10	38	150
Bowhill	21	17	21	59	11	18	21	50	16	23	13	52	24	21	20	65	226
Milne Graden	18	10	16	44	...	10	15	...	14	11	10	35	14	21	19	54	...
Yester	19	18	25	62	16	17	21	54	16	20	14	50	21	23	22	66	232
Thurston	21	7	20	48	10	11	18	39	12	16	12	40	19	20	18	57	184
East Linton	18	6	13	37	6	16	14	36	11	17	13	41	18	21	21	60	174
Smeaton	21	8	14	43	7	17	12	36	11	17	11	39	18	24	19	61	179
Tyndrum	8	11	9	28	5	13	15	33	8	14	6	28	23	7	7	37	126
Bailliestown	22	14	24	60	10	18	20	48	11	22	16	49	23	17	13	53	210
Glasgow	21	15	22	58	5	4	19	28	11	22	9	42	20	15	12	47	175
Greenock	21	17	22	60	12	18	21	51	12	22	13	47	24	18	16	58	216
Oban	16	16	23	55	9	20	22	51	13	18	22	53	25	13	11	49	208
Easdale	13	10	18	41	8	11	14	33	8	10	7	25	21	7	6	34	133
Calton Mör	19	16	23	58	12	17	15	44	6	21	18	45	23	10	10	43	190
Stirling	20	13	18	51	7	18	22	47	10	22	10	42	26	19	14	59	199
Balfour	21	14	20	55	3	5	20	28	8	14	7	29	9	23	16	48	160
Nookton	24	14	19	57	14	14	22	50	14	21	14	49	24	23	19	66	222
Arbroath	15	6	10	31	9	12	14	35	7	17	9	33	17	17	17	51	150
Montrose	12	5	11	28	7	12	12	31	12	20	9	41	14	21	18	53	153
Banchory	18	21	21	60	...	...	...	...	...	...	...	...	16	20	25	61	...
Aberdeen	15	12	21	48	12	19	17	48	16	24	19	59	21	21	26	68	223
Elgin	16	17	21	54	15	13	19	47	14	21	17	52	21	18	20	59	212
Dunrobin	15	17	19	51	11	16	16	43	10	18	...	...	22	19	21	62	...
Harris	23	20	27	70	10	22	16	48	19	24	21	64	28	11	21	60	242

RAINFALL, IRELAND.

DETAIL OF MONTHLY AND ANNUAL FALL AT VARIOUS PLACES.

YEAR.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	October.	Nov.	Dec.	Total.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Cork. Height 60 feet. 1851	4.57	1.91	3.15	1.59	2.28	2.24	2.61	2.32	1.51	3.60	0.83	3.99	40.64
1852	5.91	1.19	2.30	1.25	1.87	3.98	1.45	2.59	1.46	3.33	6.59	5.73	37.65
1853	5.23	0.41	1.41	2.56	1.73	1.88	2.46	2.33	2.28	6.90	4.70	1.54	33.43
1854	4.17	0.36	0.85	0.10	2.20	2.57	2.94	1.00	0.90	1.62	0.86	1.50	19.10
1855	0.27	2.42	3.24	1.17	2.86	1.76	0.92	2.50	1.54	1.02	2.07	3.76	23.53
1856	4.78	3.79	1.46	2.86	3.39	0.92	0.68	2.66	2.15	3.56	0.75	5.46	32.46
Mean	5.82	1.68	2.08	1.59	2.39	2.23	1.84	2.24	1.64	3.33	2.63	3.66	31.13
Ennis. Height 5 feet. 1851	7.97	2.64	4.85	1.94	1.56	4.18	3.04	3.11	0.90	5.83	1.82	2.24	40.08
1852	7.90	4.41	1.69	1.19	2.19	6.94	2.33	5.54	1.52	4.34	7.60	7.94	53.59
1853	8.43	1.03	1.71	3.88	1.08	2.84	4.53	2.53	3.59	6.10	4.06	0.59	40.37
1854	4.25	1.80	1.93	0.20	4.54	4.70	3.28	1.76	2.20	3.90	2.00	5.88	36.44
1855	0.96	2.53	3.07	1.48	2.77	3.47	3.36	4.23	1.29	4.36	2.01	3.17	32.70
1856	3.09	3.11	0.77	3.15	4.41	1.96	3.51	2.70	3.70	2.11	1.20	5.54	35.25
Mean	5.43	2.59	2.34	1.97	2.76	4.02	3.34	3.31	2.20	4.44	3.11	4.13	39.74
Galway. Height 35 feet. 1851	8.64	4.93	5.68	3.70	0.88	5.26	7.00	6.66	3.76	5.92	2.30	4.32	59.05
1852	21.87	8.87	1.15	0.96	1.72	6.36	1.72	3.12	1.44	3.50	7.86	8.50	67.07
1853	7.91	0.82	1.41	3.33	0.57	1.85	6.19	2.30	2.00	3.86	4.06	0.76	35.66
1854	4.94	1.68	2.05	0.25	3.41	3.97	2.88	2.15	2.53	3.70	2.76	5.13	35.45
1855	1.18	1.66	2.30	1.60	2.57	3.12	3.22	3.71	1.45	4.77	1.68	2.20	29.46
1856	2.68	3.89	0.45	2.31	3.38	2.45	3.95	2.80	4.77	1.72	2.43	6.04	36.87
Mean	7.87	3.64	2.17	2.03	2.09	3.84	4.16	3.46	2.76	3.91	3.51	4.49	43.93
Cong, Farmhill Height 250 feet. 1851	6.22	2.41	4.18	2.76	0.97	3.03	2.21	1.22	2.65	4.48	1.90	2.08	34.15
1852	7.59	4.80	0.67	1.13	2.00	6.72	2.56	4.47	1.80	3.91	5.46	11.98	53.09
1853	11.78	2.25	2.24	2.06	1.05	1.63	5.49	2.19	3.90	4.99	4.06	1.10	42.78
1854	5.31	1.80	2.27	0.50	1.77	4.39	2.84	1.60	2.61	2.81	2.12	4.25	32.30
1855	0.54	1.31	2.52	1.27	3.10	2.80	2.24	4.52	1.29	5.38	1.63	2.46	29.06
1856	3.45	3.20	0.70	2.14	2.30	2.92	2.30	2.60	3.12	2.70	1.93	5.56	32.92
Mean	5.82	2.63	2.10	1.64	1.87	3.58	2.94	2.77	2.57	4.04	2.85	4.57	37.38
Markree, Sligo. Height 146 feet. 1851	5.01	2.89	3.07	2.23	1.53	4.80	3.01	5.70	1.96	4.65	3.34	2.06	40.25
1852	6.07	4.32	0.73	1.06	1.34	5.47	3.34	5.20	2.15	4.00	4.66	7.38	45.72
1853	6.13	1.51	3.84	2.96	0.68	2.43	4.30	2.55	2.20	4.08	3.04	1.35	35.07
1854	4.24	2.21	1.87	1.07	4.08	2.96	3.15	1.80	2.73	3.86	3.87	5.70	37.50
1855	0.59	1.17	2.54	1.68	2.27	2.95	4.07	3.92	1.41	4.24	1.09	3.46	29.39
1856	2.66	2.11	0.71	0.77	2.85	2.22	3.45	3.46	2.34	1.59	2.18	3.72	28.06
1857	4.05	2.10	2.12	5.42	0.71	4.54	1.95	2.15	4.03	2.81	2.54	3.13	35.55
1858	2.27	2.12	2.49	3.82	2.86	2.18	2.97	2.81	2.29	3.60	1.03	5.61	34.05
1859	4.24	2.26	4.76	3.84	0.54	2.05	4.36	3.57	5.04	2.58	3.12	4.23	40.59
Mean	3.92	2.30	2.57	2.54	1.77	3.30	3.40	3.46	2.67	3.49	2.76	4.07	36.25
Ferbane. Height 176 feet. 1851	6.05	1.40	2.72	1.17	1.11	2.85	2.87	3.70	1.89	3.76	1.17	1.09	29.78
1852	5.89	4.37	1.17	1.09	2.42	6.15	2.28	4.11	0.95	2.09	6.27	4.51	41.30
1853	5.04	0.99	1.91	3.31	0.82	2.61	4.06	2.57	1.48	3.76	3.04	0.66	30.25
1854	5.09	1.60	1.16	0.32	2.68	3.07	2.92	1.18	1.98	2.73	1.64	3.03	27.40
1855	0.56	2.05	3.03	1.08	1.48	2.56	3.15	3.52	1.34	3.34	1.50	2.29	25.90
1856	3.16	2.03	0.51	2.16	4.75	2.01	2.29	2.26	2.95	1.95	0.80	4.28	29.15
Mean	4.30	2.07	1.75	1.52	2.21	3.21	2.93	2.89	1.77	2.94	2.40	2.64	30.63

RAINFALL, IRELAND.

DETAIL OF MONTHLY AND ANNUAL FALL AT VARIOUS PLACES.

YEAR.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	October.	Nov.	Dec.	Total.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Balna-lack. 1854	5.66	1.77	1.62	0.20	2.59	3.25	5.19	1.49	1.73	2.61	2.00	3.82	31.85
1855	0.35	1.16	2.33	1.29	2.57	2.63	3.01	3.04	1.41	3.23	1.18	2.06	24.20
1856	1.61	2.19	0.61	1.59	2.95	3.03	2.52	3.04	3.75	1.80	1.13	4.37	28.65
Mean	2.54	1.71	1.54	1.03	2.68	2.97	3.57	2.52	2.29	2.55	1.44	3.39	28.23
Belturbet. Height 190 feet. 1851	5.93	2.49	3.40	2.06	2.20	3.79	4.03	3.61	1.78	4.78	2.11	2.23	38.41
1852	7.33	5.42	1.59	1.67	1.86	6.02	5.00	4.50	1.05	3.67	5.88	8.03	52.02
1853	5.94	1.34	3.41	2.66	0.49	3.40	5.71	2.52	2.13	5.48	4.41	1.23	38.72
1854	5.17	2.35	2.12	0.25	4.35	5.26	4.56	2.87	2.00	4.16	2.16	5.74	40.99
1855	0.75	2.18	2.78	1.75	2.07	2.78	2.22	6.82	1.36	3.47	1.25	2.80	30.23
1856	1.72	3.30	0.97	1.83	2.53	1.63	3.35	4.63	2.77	2.85	1.54	3.55	30.67
Mean	4.47	2.85	2.38	1.70	2.25	3.81	4.15	4.16	1.85	4.07	2.89	3.93	38.51
Armagh. Height 235 feet. 1851	5.53	2.83	2.55	1.54	1.91	3.45	3.65	2.81	2.44	2.90	1.41	2.13	33.13
1852	7.81	5.72	1.28	1.44	1.18	5.66	1.70	2.88	1.81	2.56	7.54	8.91	48.49
1853	4.68	1.28	1.89	3.13	0.49	2.26	3.58	2.47	1.34	4.98	3.99	1.60	31.69
1854	4.59	2.62	2.09	0.21	2.57	4.64	4.78	2.45	2.09	3.41	2.92	6.24	38.61
1855	0.61	1.59	2.54	2.27	2.70	2.25	2.40	3.30	1.41	3.40	0.73	2.28	25.48
1856	2.26	2.27	0.75	1.05	3.01	2.09	1.49	2.69	3.49	1.49	1.47	3.86	25.92
1857	4.62	2.07	3.93	4.58	1.21	1.76	2.74	2.66	2.09	1.73	3.48	2.75	33.60
1858	2.05	1.52	1.57	5.86	3.37	0.94	2.94	3.14	2.06	2.76	1.23	4.59	32.03
1859	4.36	2.69	4.04	3.42	0.47	1.32	1.90	3.40	4.27	1.47	3.87	3.33	34.53
Mean	4.06	2.51	2.29	2.61	1.88	2.71	2.80	2.87	2.33	2.74	2.96	3.96	33.72
Toome. Height 60 feet. 1851	5.50	2.16	2.81	0.88	1.29	2.45	2.06	3.20	1.87	3.26	2.03	1.75	29.26
1852	4.97	4.44	1.21	1.92	2.28	3.72	1.93	3.69	1.17	1.83	6.02	6.78	39.96
1853	3.70	1.56	1.03	0.29	2.71	3.51	5.17	3.26	1.94	2.62	1.67	3.60	31.06
1854	4.82	1.14	1.94	2.10	0.19	1.98	3.35	3.13	1.39	4.31	3.63	0.52	28.50
1855	0.21	0.43	1.75	0.95	2.46	2.46	1.53	3.15	4.36	0.69	3.03	0.75	21.77
Mean	3.84	1.94	1.75	1.23	1.79	2.82	2.81	3.29	2.14	2.54	3.28	2.68	30.11
Belfast. Height 65 feet. 1851	4.54	1.94	2.86	1.81	1.19	4.43	2.72	3.40	1.68	3.80	1.13	1.31	30.34
1852	4.74	4.39	1.10	2.26	1.71	4.85	2.39	4.03	1.04	1.51	6.01	7.11	41.14
1853	5.10	1.76	2.65	4.19	0.59	1.83	4.84	2.72	0.89	5.51	2.53	1.10	33.71
1854	3.25	1.62	1.31	0.42	1.93	3.23	3.07	3.04	1.60	2.62	3.07	4.62	29.78
1855	0.50	1.69	2.68	1.74	2.63	1.76	2.19	3.11	1.72	3.98	0.95	1.84	24.82
1856	2.21	2.12	1.05	2.06	3.47	3.00	2.06	2.89	3.62	1.77	1.91	3.86	29.84
1857	4.21	1.96	4.43	3.99	1.37	2.16	1.63	1.69	2.29	1.63	2.91	1.49	29.76
1858	1.97	1.27	1.81	6.34	4.52	1.55	3.64	2.55	2.95	2.59	1.16	5.00	35.37
1859	3.00	2.61	2.93	3.07	0.17	1.83	1.71	1.92	3.51	2.35	3.99	3.09	30.18
Mean	3.32	2.16	2.22	2.87	1.95	2.73	2.69	2.82	2.14	2.86	2.63	3.27	31.67
Cas. Bellingham Height 70 feet. 1848	1.25	3.00	1.97	1.96	0.67	3.22	2.42	4.34	2.04	2.74	1.33	1.91	26.85
1849	2.20	0.84	0.64	1.84	1.41	0.20	2.29	2.27	2.36	3.85	1.20	1.93	21.03
1850	2.54	1.49	0.06	2.54	1.79	1.36	2.63	1.56	2.15	1.05	1.58	1.25	20.03
1851	3.81	0.69	0.72	1.10	1.79	2.43	1.91	3.05	0.85	3.02	0.81	1.86	22.04
1852	2.71	1.81	0.09	1.65	1.70	5.40	1.43	2.25	0.29	3.61	5.97	3.35	31.26
1853	2.22	...	0.68	2.22	0.36	2.37	4.06	1.76	1.43	4.30	3.68	1.74	24.82
1854	4.60	0.69	1.24	0.09	2.37	3.29	3.83	1.38	0.74	2.86	2.14	2.70	25.93
Mean	2.76	1.22	1.05	1.63	1.44	2.61	2.65	2.37	1.41	3.06	2.39	1.97	24.56

TABLE OF MONTHLY RAINFALL,

At Dublin from 1837 to 1852, and at Limerick from 1840 to 1846.

With the Maximum Rainfall in 24 hours for each month, during the same period.

DUBLIN.

Longitude 6° 15′; Latitude 53° 21′; Gauge 19 feet above Sea.

	Year.	Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Rainfall.		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
	1837	1.10	2.51	0.83	1.90	2.05	1.92	4.07	1.47	2.69	1.87	1.86	2.84	25.11
	1838	1.22	4.62	1.73	2.59	1.62	2.34	2.48	3.56	0.66	1.85	4.18	1.59	28.44
	1839	2.57	1.49	2.44	1.24	0.84	2.27	6.17	4.41	6.08	3.96	4.12	3.34	38.93
	1840	3.37	1.98	0.34	1.23	3.40	1.73	3.19	3.50	1.84	2.30	4.23	1.66	28.77
	1841	1.71	1.18	1.68	1.10	2.37	2.05	2.77	2.96	1.48	4.83	2.79	3.27	28.19
	1842	1.20	2.88	2.30	1.00	3.68	2.23	3.18	1.58	3.46	1.73	5.23	1.12	29.59
	1843	1.89	1.59	1.50	2.99	4.63	2.89	2.25	2.02	1.24	3.91	2.55	0.40	27.86
	1844	1.72	2.51	2.06	1.20	0.30	1.50	2.06	3.70	2.85	2.82	5.00	2.37	28.09
	1845	3.41	0.70	1.52	0.84	1.60	3.30	2.79	2.43	1.04	2.70	2.77	3.11	26.21
	1846	2.89	0.85	2.30	5.51	1.78	0.98	2.92	4.78	2.15	3.37	1.46	1.08	30.07
	1847	2.79	2.44	1.05	2.71	2.30	1.75	0.80	1.51	1.53	1.92	2.38	2.86	24.04
	1848	1.56	3.62	2.25	2.53	1.57	3.33	2.20	4.25	2.75	4.40	1.40	2.16	32.02
	1849	3.05	0.81	1.03	2.73	2.20	0.40	2.37	3.92	3.57	4.12	1.72	3.24	29.16
	1850	2.87	1.81	0.70	3.69	2.22	1.66	2.60	1.56	2.05	1.53	2.27	3.07	25.92
	1851	4.24	0.99	2.39	1.68	1.11	2.96	2.67	2.09	0.93	3.33	1.05	0.89	24.33
	1852	3.04	2.67	0.69	1.15	3.52	6.14	2.12	3.68	2.96	2.97	5.91	3.68	38.53
Mean		2.41	2.04	1.55	2.13	2.20	2.34	2.78	2.96	2.33	2.97	3.05	2.29	29.08
Maximum Days' Rain.														
	1837	.34	.48	.34	.31	.37	.67	1.08	.86	.60	.35	.43	.89	
	1838	.30	.92	.32	.52	.49	.49	.57	.57	.27	.56	1.10	.42	
	1839	1.15	.49	.49	.44	.54	.88	1.42	1.47	1.00	.70	1.30	.91	
	1840	.40	.55	.14	.54	.90	.45	.41	1.54	.28	.88	1.16	.73	
	1841	.43	.22	.26	.22	.77	.61	.37	.67	.49	1.02	.77	.84	
	1842	.30	.69	.45	.68	.54	.57	1.10	.66	.82	.76	1.18	.31	
	1843	.37	.53	.44	.44	1.50	.64	.29	.28	.80	.87	.38	.09	
	1844	.46	.55	.43	.46	.14	.53	.36	1.73	.98	1.09	1.10	.79	
	1845	.52	.25	.29	.23	.29	1.08	1.05	.84	.28	.77	.52	1.02	
	1846	.43	.34	.35	1.35	.37	.21	.73	1.43	.93	.39	.45	.24	
	1847	.76	.78	.35	.32	.46	.39	.32	.73	.49	.28	.81	.52	
	1848	.33	.47	.65	.49	.88	.81	.39	.65	1.24	.74	.31	.47	
	1849	.81	.22	.37	.52	.79	.13	.81	1.18	1.07	1.09	.50	1.00	
	1851	.84	.38	.43	.38	.39	.63	.45	.46	.51	1.07	.15	.20	
	1852	.31	.67	.36	.46	1.37	1.24	.54	.53	1.64	1.03	1.55	.67	
Mean		.51	.50	.37	.49	.65	.62	.65	.90	.76	.77	.78	.60	

LIMERICK.

Longitude 8° 36′; Latitude 52° 30′; Gauge 65 feet above Sea.

	Year.	Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Rainfall.		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
	1840	3.35	2.58	0.19	0.88	2.60	2.52	4.17	4.73	3.15	1.01	3.49	2.25	30.92
	1841	2.02	1.92	3.79	2.51	2.17	1.91	3.04	5.45	3.09	4.95	3.53	3.72	38.10
	1842	3.72	3.16	4.63	1.05	2.62	2.79	2.52	1.26	2.97	1.30	3.43	2.13	31.58
	1843	2.56	0.71	2.08	4.17	4.45	2.89	3.93	2.58	2.33	4.19	4.64	1.37	35.90
	1844	2.80	5.40	4.62	2.31	0.20	2.61	1.85	4.29	3.06	5.13	4.16	1.88	38.30
	1845	4.74	1.35	1.44	2.25	1.48	2.45	4.12	3.15	3.25	2.41	4.53	3.69	34.86
	1846	4.61	1.18	3.59	4.25	1.30	0.65	2.53	5.39	1.69	5.09	3.50	0.86	34.64
Mean		3.39	2.33	2.90	2.49	2.11	2.26	3.16	3.83	2.79	3.44	3.89	2.27	34.90
Maximum Days' Rain.														
	1840	.32	.49	.04	.22	.44	.28	.57	1.22	.33	.44	.86	.26	
	1841	.26	.70	.74	.33	.45	.42	.48	.65	.46	1.03	.31	.54	
	1842	.54	.57	.85	.61	.51	.80	.61	.37	.63	.25	.56	.40	
	1843	.28	.10	.62	.62	1.40	.62	1.53	.42	1.25	.45	.46	.29	
	1844	.51	1.42	.68	.75	.11	.44	.38	1.12	1.11	1.38	.74	.56	
	1845	.52	.18	.48	.54	.31	.59	.54	1.33	.96	1.23	.54	.50	
	1846	.47	.31	.53	.35	.13	.13	.27	1.53	.48	.53	.33	.32	
Mean		.41	.54	.56	.49	.48	.47	.62	.95	.74	.61	.54	.41	

MOUNTAIN RAINFALL.

PENTLAND HILLS, NORTH BRITAIN.

Note.—Reference to this table will be found at page 285; the Rainfall at Glencorse is given from 1831 to 1846 at page 300.

DETAILS OF MONTHLY FALL.

Period.		Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Colzium..... 1,030 feet above the Sea. West Base of Hills.	1849	5.9	1.7	1.5	2.5	2.0	1.9	2.9	3.2	1.9	2.1	3.4	1.8	30.8
	1850	1.7	5.8	0.7	1.4	2.7	2.4	3.2	3.7	2.1	2.5	5.2	3.2	34.6
	1851	4.9	1.7	3.8	4.6	1.1	6.4	6.8	7.4	3.5	4.6	1.7	1.9	48.4
	1852	9.2	6.7	5.7	2.9	1.3	4.2	4.1	5.3	2.3	7.3	6.8	14.7	70.5
	1853	6.0	2.0	1.4	3.7	7.2	6.2	7.8	3.6	2.7	6.2	2.1	2.0	50.9
	1854	4.2	3.2	2.9	1.2	4.4	5.5	1.9	2.0	2.5	3.9	5.6	8.3	45.6
	1855	1.7	1.3	1.1	2.5	2.1	3.2	2.4	3.6	0.8	6.8	2.0	2.1	29.6
	1856	3.2	3.9	0.1	2.7	4.2	4.8	3.2	4.7	8.5	1.5	1.2	7.5	45.5
	1857	4.2	2.8	4.2	4.5	1.7	3.3	1.8	1.8	6.5	4.0	3.0	4.5	42.3
	1858	3.3	1.3	2.5	2.3	3.8	2.4	5.6	1.8	3.3	6.8	1.4	3.4	37.9
	1859	4.5	4.5	6.6	4.2	0.2	2.0	3.3	2.1	3.5	4.3	4.2	3.4	42.8
	1860	4.0	4.7	3.8	1.2	2.2	5.0	2.0	4.0	1.5	5.6	2.8	3.0	40.4
	Mean	4.4	3.3	2.9	2.7	2.8	4.0	3.7	3.6	3.3	4.6	3.3	4.7	43.3
Glen Cottage, near Glencorse ..... 735 feet above the Sea. East Base of Hills.	1847	1.6	1.6	1.0	2.4	4.6	2.0	1.2	1.1	2.4	3.4	1.9	4.0	27.2
	1848	0.6	6.7	4.4	1.9	1.0	3.3	2.4	2.3	1.6	5.3	4.2	1.8	35.5
	1849	6.4	1.4	1.4	2.1	2.3	1.1	3.4	2.7	1.8	3.2	2.7	1.8	30.3
	1850	2.8	6.2	0.5	1.4	4.0	1.5	2.7	3.3	2.1	2.6	6.0	3.4	36.5
	1851	6.5	2.7	5.7	4.0	1.0	3.8	3.2	5.5	4.1	3.0	2.0	1.6	43.1
	1852	7.0	5.3	0.9	0.4	2.6	3.0	2.3	5.5	3.5	4.8	4.0	9.9	49.2
	1853	4.5	2.2	0.8	2.6	1.1	5.2	4.1	3.5	2.8	5.8	1.8	2.6	37.0
	1854	3.9	2.6	2.0	1.9	3.7	5.9	2.5	2.4	1.4	2.8	4.4	4.3	37.8
	1855	1.9	2.5	1.8	1.2	2.4	3.1	4.0	4.3	0.8	4.2	1.9	1.7	29.8
	1856	3.1	2.9	0.1	3.5	3.7	5.2	2.4	4.6	7.4	1.3	1.4	5.2	40.8
	1857	3.0	1.6	2.4	2.6	2.1	5.4	1.6	2.2	6.2	2.1	3.8	3.2	36.2
	1858	2.5	1.1	1.6	1.3	2.9	1.7	4.0	1.8	2.2	4.7	1.4	2.4	27.6
	1859	4.0	2.5	5.0	3.6	0.1	1.7	3.1	1.4	2.2	4.0	3.2	2.6	33.4
	1860	4.8	2.9	3.5	0.9	1.0	3.9	1.2	1.9	1.1	3.4	2.1	3.0	29.7
	1861	2.3	2.8	3.5	2.3	0.8	2.6	4.2	4.0	4.5	1.8	8.0	1.3	38.1
	Mean	3.7	3.0	2.3	2.1	2.2	3.3	2.8	3.1	2.9	3.5	3.3	3.3	35.5
Swanston ... 550 feet above the Sea. North Slope of Hills.	1850	2.1	4.4	0.3	1.3	3.4	1.5	2.2	2.8	2.0	1.7	3.6	2.6	27.9
	1851	4.4	1.4	4.1	2.7	1.0	3.2	2.9	4.5	2.3	2.4	1.6	0.9	31.4
	1852	6.7	3.8	0.9	0.3	1.4	3.7	2.1	5.1	2.7	3.3	4.3	9.1	43.4
	1853	4.2	2.9	1.2	1.4	1.4	6.6	3.2	4.3	2.5	5.1	1.7	2.2	36.7
	1854	4.4	2.4	1.8	0.8	3.2	5.1	2.0	2.2	1.1	2.4	3.9	3.1	32.4
	1855	1.6	1.9	1.3	0.9	2.0	3.2	3.6	5.0	0.4	3.3	1.8	1.6	26.6
	1856	2.9	2.7	0.1	2.9	4.6	4.3	2.2	4.2	7.1	1.8	1.4	4.5	38.7
	1857	1.9	0.9	2.5	2.5	1.9	4.8	1.8	2.6	5.9	2.1	3.7	3.0	33.6
	1858	2.6	1.4	1.4	1.0	2.8	1.7	4.8	2.2	2.8	6.6	2.0	2.0	31.3
	1859	4.5	2.9	4.8	3.7	0.2	2.3	3.4	1.0	2.3	4.0	3.0	3.4	35.5
	1860	5.4	2.8	3.0	0.8	1.5	3.1	1.6	2.9	1.0	4.4	3.2	3.4	33.1
	1861	1.7	2.3	3.4	2.0	1.0	2.9	4.7	3.7	5.8	1.6	6.6	1.6	37.3
	Mean	3.5	2.5	2.1	1.7	2.1	3.6	2.9	3.4	2.9	3.2	3.0	3.1	34.0
Harelaw..... 876 feet above the Sea. N.W. Slope of Hills.	1856	2.6	3.1	0.1	3.2	4.1	4.2	2.3	4.4	8.2	1.3	0.9	4.4	38.8
	1857	2.3	0.9	2.1	2.9	2.0	5.1	2.4	2.4	5.8	2.6	3.2	2.9	34.6
	1858	2.6	1.5	1.3	1.6	2.8	1.5	5.0	2.4	3.0	6.6	2.0	2.1	32.4
	1859	4.1	2.7	4.5	4.1	0.2	2.1	3.5	1.3	2.6	4.7	3.1	3.8	36.7
	1860	6.3	2.3	3.0	0.8	1.4	4.5	2.0	4.0	1.1	4.5	2.7	4.5	38.1
	1861	1.5	2.9	4.1	2.5	1.0	3.1	4.5	4.5	5.5	2.2	6.6	1.9	40.3
	Mean	3.2	2.2	2.5	2.5	1.9	3.4	3.3	3.2	4.4	3.6	3.3	3.3	36.8

RAINFALL OF GREAT BRITAIN.

AT STATIONS BETWEEN MANCHESTER AND GRIMSBY,

For the years 1858-9-60, from Returns kept by Robert Smith, Esq., Manager of the Sheffield and Lincolnshire Canals.

1858.	Jan	Feb	Mar	Apr	May	Jne	Jly.	Aug	Sep	Oct.	Nov	Dec	Total
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Manchester ...	2.01	1.88	2.30	2.63	2.37	3.52	2.72	4.47	3.73	5.20	1.55	4.10	36.48
Fairfield	2.00	0.01	2.00	2.83	2.39	1.69	2.63	3.20	3.02	4.28	1.34	3.72	29.11
Waterhouses ...	1.70	0.10	1.50	1.40	1.80	2.80	0.70	0.60	1.85	3.82	0.54	4.72	21.53
Newton	1.68	0.13	1.34	1.85	2.49	2.92	3.04	3.46	2.76	2.42	1.46	3.79	27.33
Mottram	1.05	0.34	1.34	2.31	1.69	3.36	3.02	3.55	2.94	3.59	1.45	4.29	28.93
Woodhead	0.92	0.68	2.29	3.50	3.05	4.57	2.91	3.58	3.66	6.83	1.55	4.25	37.79
Dunford Bridge	2.20	0.34	1.88	3.65	4.10	4.47	2.88	3.04	3.72	5.45	1.60	4.82	38.15
Sheffield (?) ...	0.46	0.10	0.48	3.08	0.84	1.64	0.71	2.21	1.51	2.44	0.38	0.94	14.79
Chesterfield ...	0.53	0.38	0.77	3.73	1.37	1.36	1.84	4.34	2.03	4.65	0.88	2.07	23.95
Norwood.....	0.40	0.38	0.74	3.33	1.88	1.79	1.62	2.57	1.75	4.91	0.99	1.66	22.02
Worksop.....	0.23	0.33	0.59	3.01	1.13	2.32	1.56	2.14	1.87	5.21	0.61	1.90	20.90
Retford (?).....	0.26	0.14	0.44	2.26	1.31	1.21	1.69	1.94	2.06	3.82	0.88	1.69	17.70
Stockwith	0.37	0.27	1.15	1.64	1.54	1.51	2.21	3.14	1.96	3.56	1.05	1.59	19.99
Marple A.	1.16	0.14	1.54	1.21	2.01	2.40	1.97	2.64	2.08	3.15	0.79	1.38	20.47
Macclesfield ...	1.05	0.10	0.45	3.15	3.38	3.66	2.95	2.74	3.17	3.83	1.05	2.94	28.47
Whaley	1.22	0.09	1.54	2.76	1.67	4.95	2.22	3.93	3.11	4.89	1.65	5.86	33.89
Combs R.	0.90	0.04	1.79	2.89	2.99	4.94	2.74	4.59	3.77	4.66	1.47	4.76	35.54
Combs Moss ...	0.78	0.10	2.17	2.20	2.20	3.80	1.57	2.14	4.82	6.48	1.97	4.01	32.24
Chapel-le-Frith	1.02	0.07	2.07	2.21	2.95	6.16	2.92	4.13	4.19	5.35	1.53	4.05	36.65
Bollington	1.15	0.13	0.89	2.22	1.59	4.85	2.11	3.83	3.43	5.25	2.06	6.69	34.20
Bosley R.	0.99	0.12	1.20	2.23	2.31	4.25	2.70	2.86	2.87	3.22	1.14	2.93	26.82
Bosley Minns...	1.06	Nil.	1.72	2.62	2.64	4.07	2.30	3.30	3.21	3.82	1.41	2.46	28.61

1859.	Jan	Feb	Mar	Apr	May	Jne	Jly.	Aug	Sep	Oct.	Nov	Dec	Total
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Manchester ...	2.01	2.85	4.59	2.90	0.31	2.13	1.97	7.06	4.12	3.49	3.44	3.26	38.13
Fairfield	2.86	1.62	4.20	3.09	0.28	2.49	2.79	7.28	6.13	3.03	2.75	3.16	39.68
Waterhouses ...	1.50	2.05	3.94	2.19	0.63	1.43	3.14	5.42	5.96	2.81	2.14	3.18	34.68
Newton	2.32	2.43	4.03	2.77	0.40	1.84	2.06	6.92	4.76	2.80	1.71	4.84	34.88
Mottram	1.70	2.28	4.47	2.28	0.26	2.07	1.31	6.45	4.67	1.76	2.56	1.80	31.61
Woodhead	1.95	3.33	6.43	6.29	0.38	3.42	2.44	0.69	7.14	5.05	5.34	5.18	57.64
Dunford Bridge	2.96	3.19	6.75	7.97	0.36	3.26	1.65	9.84	6.33	7.02	4.13	5.10	58.56
Penistone	1.62	1.90	3.03	5.27	1.08	3.36	0.86	6.18	3.15	4.82	3.58	4.81	39.66
Marple A.	1.45	2.02	3.73	2.61	0.19	1.75	0.96	5.17	3.63	2.65	1.81	2.08	28.05
Marple T. L. H.	1.12	1.86	3.58	2.83	0.32	1.70	1.33	3.71	2.02	2.31	2.58	2.14	25.50
Macclesfield ..	1.45	1.78	4.07	3.72	0.64	2.06	1.69	4.79	3.77	2.85	2.49	2.19	31.50
Whaley	2.76	2.93	7.79	5.45	0.79	3.79	1.65	6.46	4.37	2.97	3.86	2.22	45.04
Combs R.	2.85	3.49	6.70	5.12	0.77	1.63	1.44	5.62	4.30	3.90	4.07	3.36	43.25
Combs Moss ..	1.81	3.70	5.25	3.61	0.44	2.24	1.60	5.45	5.73	3.78	4.68	2.81	41.10
Chapel-le-Frith	2.77	2.29	5.18	4.08	0.38	1.72	1.43	5.57	4.28	2.77	3.64	3.31	38.42
Sponds Hill ...	2.92	2.56	8.04	5.28	0.33	6.16	0.89	6.95	6.20	3.32	4.11	2.56	49.32
Bosley Minns .	1.00	1.72	3.27	2.77	0.79	2.28	2.58	4.16	3.84	2.23	1.99	1.85	28.48
Bosley R.	1.17	1.78	3.37	2.66	0.43	2.02	2.56	3.22	3.13	2.55	1.89	2.25	27.03
Sheffield	0.28	0.61	2.07	3.10	0.25	2.85	1.25	4.77	2.50	3.02	2.03	2.38	25.11
Chesterfield ...	1.42	2.45	2.41	3.56	0.17	3.35	0.60	5.29	3.14	3.25	2.40	2.26	30.30
Norwood.....	0.91	1.22	1.66	3.73	0.30	2.71	0.97	4.90	2.58	3.47	2.26	2.18	26.89
Worksop.....	0.94	0.84	1.33	4.13	0.39	2.08	0.66	4.11	2.62	3.01	1.69	1.72	23.52
Retford	0.78	1.10	1.16	3.56	0.45	2.33	0.43	3.97	2.89	2.54	1.50	1.60	22.31
Stockwith	0.68	1.01	1.08	2.90	0.56	2.09	0.47	3.26	3.16	1.27	1.82	1.55	19.85
*Gainsbro'	...	...	1.06	3.04	0.74	2.35	0.33	3.29	3.09	1.42	1.46	1.33	18.11
*Lincoln	...	...	0.66	3.19	0.95	1.69	1.75	2.27	2.04	1.79	1.58	1.47	17.39
*Market Rasen.	...	...	0.91	2.84	0.91	1.80	0.91	3.47	2.83	1.98	1.71	1.75	19.11
*Brigg	...	...	1.10	2.44	0.68	1.98	0.87	2.96	3.30	1.78	1.49	1.45	18.05
*Barnetby	...	...	1.44	2.75	0.57	1.89	0.14	3.18	2.30	2.64	1.38	1.67	17.96
*New Holland...	...	...	1.07	2.93	0.44	1.82	0.83	3.51	2.63	2.54	2.05	1.85	19.67

NOTE.—At places marked with an Asterisk (*) the Gauge was kept only 10 months during 1859. Marple Aqueduct to Bosley Reservoir inclusive, form a line of Gauges across the Millstone grit range, south of those between Fairfield and Penistone; Coombs Moss being about 14 miles south of Penistone.

The Average Fall of 30 stations during 1859, 31.96 inches.
" " " " 1860, 37.28 "

1860.	Height above Sea.	JAN.		FEB.		MAR.		APRIL.		MAY.		JUNE.		JULY.		AUG.		SEPT.		OCT.		NOV.		DEC.		TOTAL.		Mean Rainfall	
	Feet	No. of days.	in.	No. of days.	in.	No. of days.	in.	No. of days.	in.	No. of days.	in.	No. of days.	in.	No. of days.	in.	No. of days.	in.	No. of days.	in.	No. of days.	in.	No. of days.	in.	No. of days.	in.	No. of days.	in.	No. of years	in.
Manchester, Piccadilly	194	17	3.61	8	0.81	21	3.79	11	1.46	20	3.36	27	7.49	12	1.91	28	5.71	17	3.17	21	4.26	14	2.56	11	3.27	207	41.40	9	32.41
Fairfield	312	17	3.59	11	1.01	24	5.24	10	1.38	17	3.39	23	5.96	12	2.30	24	5.64	14	2.91	21	4.66	16	3.05	18	2.97	207	42.10	9	30.89
Waterhouses nr. Oldm.	145	12	3.59	6	1.31	21	5.26	7	1.47	21	3.53	22	5.79	10	2.21	24	5.66	16	2.70	17	5.14	10	2.76	10	3.01	176	42.43	9	30.03
Newton	396	13	2.35	10	0.60	18	3.50	8	1.29	18	2.41	23	6.79	12	2.16	28	4.48	16	2.18	20	4.07	15	2.51	14	1.60	195	33.94	8	27.49
Mottram (Matley's fld)	396	21	2.97	10	0.48	23	4.57	9	1.34	18	3.99	28	6.47	9	2.78	25	5.12	18	2.76	20	4.26	12	2.39	12	1.80	205	38.93	6	29.60
„ Hill End	608	...	...	...	...	25	4.52	15	1.53	22	3.99	27	7.61	17	2.99	29	5.29	21	2.71	22	4.50	14	2.67	17	1.69	209	37.50	...	...
Woodhead	939	14	5.46	10	2.89	22	8.28	7	3.11	20	5.32	23	11.22	12	3.38	26	6.72	12	3.81	22	7.30	17	6.01	12	2.85	197	66.35	7	40.77
Dunford Bridge	954	19	5.16	10	2.38	22	7.52	10	2.28	22	4.57	25	10.13	12	3.26	27	7.13	18	3.43	24	7.13	20	5.63	12	4.17	221	52.79	4	50.80
Carlcotes	1072	...	...	...	...	...	...	11	2.09	21	3.59	28	7.88	12	2.69	26	6.05	18	2.78	27	6.12	24	3.40	14	2.48	181	37.08	...	...
Penistone	717	17	4.21	15	1.86	22	3.30	12	1.39	21	2.83	26	4.05	18	1.62	31	3.75	22	1.27	27	2.15	25	1.84	12	1.84	248	30.11	6	24.18
Marple Aqueduct	321	19	2.30	10	0.69	24	5.34	10	1.18	19	4.52	26	6.30	13	2.39	27	5.59	19	2.51	22	4.76	11	2.22	10	2.07	210	39.87	9	26.23
„ Top Lock House	543	14	2.56	6	0.45	27	3.64	10	0.89	18	3.03	24	4.94	11	1.60	28	4.05	10	1.56	20	3.58	9	1.42	9	1.56	186	29.28	4	24.54
Macclesfield	539	19	3.47	9	0.81	27	4.50	10	1.41	17	3.06	19	5.44	12	2.56	27	6.53	12	2.38	14	3.33	14	2.31	10	2.84	190	38.64	5	30.78
Whaley	602	9	3.97	3	0.39	18	7.81	8	1.84	13	4.30	23	6.98	14	3.58	26	5.62	11	2.65	18	5.15	15	2.56	9	1.99	167	46.84	10	33.91
Coombs Reservoir	710	16	5.28	8	1.17	23	7.24	11	1.87	16	4.29	23	7.00	12	3.93	24	7.14	16	3.27	22	6.02	18	3.51	15	3.45	204	54.17	7	36.26
Coombs Moss	1669	...	4.39	...	0.93	...	3.96	...	1.46	...	4.10	...	9.23	...	3.60	...	8.88	...	3.52	...	6.15	...	4.01	...	2.77	...	53.00	5	38.97
Chapel-en-le-Frith top of inclined plane	965	19	4.34	10	1.16	25	5.62	8	1.50	20	3.70	28	6.02	15	3.39	29	6.34	14	2.68	23	4.93	21	2.91	15	2.40	227	44.99	7	35.44
Sponds Hill, Bolingtn	1279	...	4.20	...	0.49	...	7.92	...	2.08	...	4.56	...	6.57	...	3.88	...	6.07	...	2.86	...	5.44	...	2.64	...	1.90	...	48.61	6	35.94
Bosley Minns	1210	12	2.85	4	0.50	13	2.30	5	0.95	13	3.34	20	5.77	9	2.27	21	6.93	11	2.98	12	3.37	11	2.60	7	2.35	138	36.21	9	32.92
„ Reservoir	590	16	3.03	6	0.65	22	3.24	6	1.09	14	2.80	19	5.12	11	2.15	25	6.66	12	2.50	14	2.63	11	2.03	8	2.13	164	34.03	6	27.73
Sheffield Station	188	15	3.43	11	0.62	19	1.60	13	0.69	16	2.17	26	4.12	9	1.97	22	3.77	16	2.09	17	2.39	19	2.40	14	2.33	197	27.58	5	21.30
„ The Edge	336	...	...	...	...	25	2.66	15	1.28	18	2.97	29	4.28	11	1.80	23	4.89	18	2.67	24	3.11	23	2.86	15	3.48	201	30.00	...	...
Chesterfield	248	14	4.16	7	0.64	14	2.36	6	0.69	11	3.35	14	4.26	5	1.20	16	4.45	8	2.05	13	1.72	14	2.30	11	2.36	133	29.54	5	27.56
Norwood	238	15	3.59	15	0.63	20	1.97	13	0.81	15	1.99	22	3.48	14	1.85	24	3.94	11	2.02	21	2.05	22	2.70	26	2.63	218	27.66	5	25.78
Worksop	127	18	3.29	13	1.54	19	1.90	12	0.59	13	2.78	22	3.93	10	2.55	27	5.53	12	2.38	21	1.97	18	2.48	14	1.67	217	30.61	5	25.20
Retford	52	19	3.44	6	0.53	15	2.07	10	0.54	15	2.50	21	2.10	10	2.07	23	4.75	14	3.86	14	1.64	20	2.17	15	2.46	182	28.13	5	23.48
Stockwith	21	13	3.63	7	0.64	8	1.72	4	0.71	10	2.96	13	2.93	8	1.77	15	4.28	7	2.88	8	1.35	10	2.19	5	1.40	108	26.46	4	23.13
Gainsbro.'	76	15	3.04	7	0.53	17	2.01	8	0.46	18	2.83	19	3.19	11	2.81	22	4.75	10	3.60	12	1.11	20	2.56	14	2.42	173	29.31	...	...
Gate Burton	96	...	...	...	...	...	...	13	0.47	18	2.51	22	4.01	13	1.94	24	4.93	12	3.24	18	1.71	23	2.11	17	2.39	160	23.31	...	...
Lincoln	26	11	2.46	9	0.85	15	2.35	4	0.45	14	3.50	17	3.42	10	2.14	16	4.29	10	2.43	10	1.48	13	1.77	12	2.01	141	36.15	...	...
Market Rasen	100	11	3.74	6	0.91	13	2.30	5	0.49	10	2.51	19	4.30	9	1.93	16	4.49	13	2.60	8	1.92	17	2.29	11	1.31	138	28.79	...	...
Brigg	16	15	3.55	10	1.11	13	2.60	7	0.79	14	3.37	22	4.40	12	1.72	16	3.96	10	2.14	6	1.10	16	2.52	14	2.01	155	29.27	...	...
Barnethy	51	17	3.00	14	0.84	23	2.26	6	0.88	12	2.35	25	4.34	12	1.51	21	3.52	11	2.93	11	1.45	23	2.30	14	1.66	189	27.04	...	..
New Holland	18	13	3.18	7	0.82	17	2.17	8	0.84	14	2.70	22	4.66	8	1.20	20	4.52	10	2.35	8	1.37	15	2.71	9	1.96	151	28.48	...	...
Grimsby (?)	42	18	1.94	10	1.48	21	2.09	9	0.74	11	2.13	19	2.79	10	2.55	16	2.45	10	2.58	9	0.96	14	1.64	11	0.94	158	22.29	...	...

RAINFALL—MOUNTAIN DISTRICT OF CUMBERLAND,

From 1847 to 1853.

Name of Station.	Whitehaven.	The Flosh near Whitehaven.	Keswick.	Loweswater.	Fort of Crummock Lake.	Gatesgarth.	Eskdale Head.	Wastdale Head.	Kendal.	Selside, near Kendal.	The How, Troutbeck.	Ambleside.	Langdale Head.	Seathwaite.	Stonethwaite.	The Pike.	Great Gabel.	Sprinkling Tarn.	Brant Rigg.	Seatollar Common.	The Skye.
Height in Feet .	90	...	258	336	260	290	...	247	126	736	503	190	250	368	340	3166	2925	1900	924	1338	948
Year.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
1847.....	42.92	47.80	58.28	66.30	82.32	106.2	74.9	96.3	52.2	...	78.0	...	112.9	129.2	106.2	...	...	...	...	...	...
1848.....	47.34	60.82	66.40	76.67	98.07	133.5	86.8	115.3	56.3	...	91.3	77.6	130.4	160.9	130.2	94.7	91.3	148.6	109.2	139.5	...
1849.....	39.00	45.13	48.80	55.28	70.21	97.1	71.2	107.2	48.1	70.4	75.4	65.3	107.8	125.5	94.3	83.2	84.9	121.1	87.3	109.0	...
1850.....	40.47	51.28	59.53	68.80	85.66	108.8	81.7	108.8	49.6	76.4	79.8	79.8	126.6	144.0	105.8	80.3	87.3	127.8	91.1	138.8	174.3
1851.....	43.12	51.66	62.32	67.10	84.08	107.0	78.6	97.9	47.3	70.6	80.8	84.2	116.8	139.6	114.1	71.3	85.7	134.8	89.5	141.4	169.6
1852.....	50.03	55.18	79.97	80.53	103.40	134.9	88.8	109.6	65.3	92.5	115.4	104.3	134.1	156.7	133.9	81.3	81.2	125.3	98.2	156.6	167.7
1853.....	37.40	41.38	50.44	59.61	72.09	99.1	63.1	83.4	39.4	58.0	66.0	66.3	...	113.7	95.6	56.2	59.7	94.6	73.4	111.4	124.9
Mean	42.90	50.46	60.82	67.75	85.12	112.3	77.9	102.6	51.2	73.6	83.8	79.6	121.4	138.5	111.4	77.8	81.7	125.4	91.4	132.8	159.1

NUMBER OF DAYS' RAIN.

1847.....	191	183	204	190	199	...	...	226	174	...	188	...	...	202	196	...	...	...	...	...	...
1848.....	210	207	229	217	207	...	...	243	190	...	201	...	...	332	224	...	...	...	...	...	...
1849.....	189	185	205	191	185	...	...	236	164	...	186	159	...	193	183	...	...	...	...	...	...
1850.....	189	201	209	198	204	...	...	248	168	...	185	182	...	222	199	...	...	...	...	...	...
1851.....	196	204	211	202	206	...	...	232	173	...	195	178	...	219	206	...	...	...	...	...	...
1852.....	190	194	204	201	194	...	...	212	194	156	202	204	...	221	207	...	...	...	...	...	...
1853.....	194	202	172	189	183	...	...	203	150	125	173	149	...	217	191	...	...	...	...	...	...
Mean	194	196	205	198	197	...	...	228	173	140	190	174	...	229	201	...	...	...	...	...	...

LAKE DISTRICT—DETAILS OF MONTHLY RAINFALL, For 1852 and 1853.

Name of Station, ...	Whitehaven.	The Flosh near Whitehaven.	Keswick.	Loweswater.	Foot of Crummock Lake.	Gatesgarth.	Eskdale Head.	Wastdale Head.	Kendal.	Selside near Kendal.	The How, Troutbeck.	Ambleside.	Langdale Head.	Seathwaite.	Stonethwaite.	The Pike.	Great Gabel.	Sprinkling Tarn.	Brant Rigg.	Seatollar Common.	The Stye.
Height in Feet ...	90	...	258	336	260	290	...	247	126	736	503	190	250	368	340	3166	2925	1900	924	1338	948
1852.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	8.01	9.09	14.64	14.86	19.76	24.76	15.54	17.32	9.88	14.15	21.73	20.37	22.37	27.07	24.56	Frozn	...	19.25	13.24	30.08	27.60
February	3.55	4.75	7.05	6.56	9.08	13.89	8.67	13.07	7.90	13.87	15.72	13.00	17.55	20.05	15.72	,,	...	...	10.29	19.76	22.18
March	0.26	0.23	0.38	0.27	0.60	0.62	0.37	0.70	0.21	0.29	0.26	0.23	0.30	0.98	0.81	,,	...	15.43	0.53	1.07	0.92
April	1.19	1.21	0.55	0.66	0.63	0.75	1.95	1.47	1.11	1.19	0.96	0.91	0.90	0.74	0.60	18.63	15.80	1.08	1.06	0.67	0.86
May	4.20	4.95	4.58	5.37	7.24	10.45	5.78	8.83	4.05	6.05	5.34	6.31	7.41	11.59	8.64	6.63	6.48	11.04	7.69	11.38	12.04
June	3.51	3.90	5.98	5.02	7.54	10.55	7.34	8.75	4.98	8.98	7.51	5.69	10.41	12.33	9.23	8.20	8.00	18.80	9.57	12.14	14.13
July	2.92	2.46	3.02	4.57	5.26	4.94	3.93	5.65	3.44	7.57	5.05	4.72	5.96	7.65	4.60	5.68	8.00	8.40	7.07	7.13	9.08
August	5.15	6.10	6.69	7.24	8.81	10.08	9.12	9.77	7.61	7.87	9.95	8.64	9.23	12.37	9.82	8.98	10.58	13.71	10.00	11.88	14.12
September	2.13	2.26	3.55	2.74	3.72	4.42	2.69	3.20	2.12	2.81	3.89	3.49	4.71	4.64	4.23	4.00	5.07	4.72	4.34	4.50	5.43
October	3.04	3.95	4.95	5.48	6.15	7.26	6.05	7.71	3.66	4.93	5.74	4.78	7.08	8.44	5.90	8.02	6.03	7.74	7.05	8.37	9.07
November.....	5.05	5.05	9.48	8.03	11.34	15.52	10.08	11.70	7.58	8.94	13.69	11.80	15.47	17.47	16.72	Frozn	...	...	...	17.23	17.70
December.....	11.00	11.23	19.07	19.70	23.27	31.64	17.33	21.41	12.76	15.79	25.76	24.39	32.70	32.83	33.03	20.00	21.19	40.62	27.40	32.38	34.60
Total	50.03	55.18	79.97	80.52	103.40	134.88	88.85	109.38	65.35	92.48	115.36	104.33	134.09	156.74	133.86	81.30	81.25	134.79	98.24	156.59	167.72
1853.																					
January.....	5.89	6.00	11.73	13.23	15.84	21.16	10.43	13.71	6.70	10.22	17.78	13.25	...	23.12	23.99	Frozn	and	Snow[d]	...	23.02	24.20
February	2.24	2.33	1.60	3.52	2.39	2.79	2.75	3.61	1.08	1.84	2.23	1.37	...	3.84	2.95	...	...	...	...	Frozn	...
March	1.20	1.48	1.24	1.98	2.52	3.73	3.18	3.57	2.14	2.47	3.05	3.77	...	4.59	3.45	...	1.34	14.00	18.00	6.54	8.37
April	2.48	2.91	4.62	4.59	6.97	10.29	6.93	7.96	3.08	5.45	5.35	6.05	...	12.67	10.38	6.05	6.84	14.44	6.00	12.73	13.86
May	0.27	0.33	1.16	0.79	0.83	0.85	0.68	0.66	0.80	0.33	0.85	0.72	...	0.89	0.69	7.75	6.46	0.30	0.73	0.46	1.19
June	3.14	3.54	1.71	2.78	2.80	3.86	2.94	3.92	3.08	5.13	3.26	3.09	...	4.07	3.74	3.44	4.00	5.35	3.52	5.06	4.98
July	4.93	6.68	6.64	8.36	9.93	16.13	8.93	15.97	6.83	11.09	8.16	7.84	...	19.67	13.68	15.88	16.00	21.10	14.71	18.73	23.05
August	3.12	4.13	4.07	4.83	6.05	7.75	7.09	8.00	2.68	4.56	4.45	4.08	...	10.47	7.81	7.20	7.70	10.35	8.70	10.58	11.77
September	2.73	3.27	4.17	4.93	5.80	8.02	5.62	8.07	3.52	4.97	5.54	6.54	...	10.42	7.33	5.19	6.46	8.47	6.42	10.21	11.55
October	6.59	5.14	7.49	8.10	9.43	13.18	8.36	9.11	5.00	6.41	8.04	9.04	...	13.25	12.50	6.61	7.11	14.00	7.61	12.76	14.60
November.....	4.30	4.99	5.52	5.84	8.48	9.68	5.01	7.56	4.00	5.17	6.57	9.59	...	9.47	8.12	3.20	3.40	6.11	6.68	10.14	10.05
December.....	0.51	0.58	0.49	0.66	1.05	1.66	1.15	1.25	0.53	0.34	0.65	0.93	...	1.23	0.95	0.85	0.41	0.47	1.03	1.22	1.29
Total	37.40	41.38	50.44	59.61	72.09	99.10	63.07	83.39	39.45	57.98	65.97	66.27	...	113.69	95.65	56.17	59.72	94.59	73.40	111.45	124.91

DETAILS OF RAINFALL IN THE LAKE DISTRICT.

SEATHWAITE.—1845 to 1853.

Year.	Jan.	Feb.	Mar.	April	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Rainfall. 1845	16.81	3.48	13.21	10.57	4.57	8.25	8.65	15.61	9.77	15.17	20.84	24.94	151.87
1846	17.07	11.51	17.85	7.70	4.40	6.41	20.80	10.58	4.60	25.43	10.46	6.70	143.51
1847	6.29	8.27	2.53	6.81	8.08	7.27	3.32	10.48	13.28	20.52	21.85	20.54	129.24
1848	9.67	30.55	11.36	4.19	3.05	11.30	17.76	13.91	7.00	17.32	14.07	20.71	160.89
1849	24.96	7.55	5.51	3.88	6.52	3.97	16.64	9.92	4.08	16.14	18.75	7.55	125.47
1850	7.34	22.58	4.13	15.62	7.14	6.83	11.20	16.22	5.85	12.94	22.60	11.51	143.96
1851	28.63	15.33	9.36	6.08	4.53	11.63	14.47	13.16	4.30	20.38	3.74	7.99	139.60
1852	27.65	20.05	0.98	0.74	11.59	12.33	7.65	12.37	4.64	8.44	17.47	32.83	156.74
1853	23.12	3.84	4.59	12.67	0.89	4.07	19.67	10.47	10.42	13.25	9.47	1.23	113.69
Mean	17.95	13.67	7.72	7.58	5.64	8.01	13.35	12.52	7.10	16.62	15.47	14.89	140.55
Maximum Fall in 24 Hours. 1845	3.05	1.24	2.83	3.10	0.88	1.53	2.21	3.20	1.95	2.61	6.62	4.22	33.44
1846	2.50	2.18	3.80	1.60	1.10	1.84	4.01	2.54	1.44	5.98	1.51	1.62	30.12
1847	1.44	2.42	0.41	1.65	1.37	2.20	0.58	3.22	2.74	5.33	4.96	3.10	29.42
1848	1.82	3.67	2.70	0.79	0.80	2.36	3.06	3.00	1.47	3.25	2.43	4.60	29.95
1849	3.32	1.92	1.60	0.70	0.90	1.35	2.68	1.63	1.28	3.78	2.50	1.18	22.84
1850	2.60	3.21	1.45	2.00	2.80	2.20	3.24	3.21	1.89	3.71	3.15	1.18	30.64
1851	4.24	2.84	1.50	1.35	0.80	2.41	3.98	1.63	1.70	2.98	1.30	1.92	26.65
1852	4.40	3.30	0.28	0.51	2.57	1.92	1.06	2.00	1.22	1.27	3.05	4.57	26.15
1853	3.84	1.12	1.04	3.75	0.22	0.74	4.28	2.52	1.93	1.80	1.63	0.36	23.23
Mean	3.02	2.43	1.73	1.72	1.27	1.84	2.70	2.55	1.74	3.41	3.02	2.53	28.05

UNUSUAL FALLS OF RAIN.

Date.	Hours falling.	Inches fallen.	Date.	Hours falling.	Inches fallen.
November, 1845	48	9.62	December, 1848	48	6.74
March, 1846	48	6.86	February, 1850	72	6.91
October, 1846	48	9.74	October, 1850	48	5.91
October, 1846	72	11.63	January, 1851	48	5.34
October, 1847	48	6.76	July, 1851	72	8.27
November, 1847	48	8.36	October, 1851	48	5.63
February, 1848	72	7.72	February, 1852	120	11.15
October, 1848	48	5.89	December, 1852	48	7.60

Number of Days' Rain in the Lake District for 1852 & 1853.

1852.	Jan.	Feb.	Mar.	April	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Whitehaven	23	16	5	4	12	19	15	19	10	16	21	30	190
The Flosh	23	16	4	4	13	21	13	19	13	15	23	30	194
Keswick	29	15	4	4	14	25	14	20	13	16	22	28	204
Loweswater	27	18	4	3	13	21	15	21	14	15	22	28	201
Crummock L.	26	16	4	3	14	20	15	19	10	16	21	30	194
Wastdale Head	26	17	5	3	14	26	15	19	15	18	24	30	212
Kendal	24	13	3	3	15	21	14	17	14	15	24	31	194
Selside	24	16	4	4	14	15	17	17	5	8	10	22	156
Troutbeck	26	18	5	3	10	21	15	19	15	17	24	29	202
Ambleside	25	15	3	4	14	21	16	28	11	15	24	28	204
Langdale Head	27	17	5	4	15	26	18	19	14	16	23	30	214
Seathwaite	28	17	6	3	16	25	18	22	16	17	23	30	221
Stonethwaite	26	16	6	3	16	25	16	19	14	16	21	29	207
1853.													
Whitehaven	20	17	14	18	5	16	21	13	15	24	17	14	194
The Flosh	22	13	17	19	6	17	22	14	18	22	18	14	202
Keswick	19	12	12	16	6	11	21	10	14	26	14	11	172
Loweswater	22	15	14	18	7	15	19	12	18	21	17	11	189
Crummock L.	21	11	15	18	6	13	19	12	16	22	18	12	183
Wastdale Head	22	13	17	20	4	16	23	14	19	25	18	12	203
Kendal	22	5	13	17	5	11	21	9	12	18	13	4	150
Selside	20	4	10	12	1	12	18	10	12	15	8	3	125
Troutbeck	22	8	16	20	5	12	22	10	16	20	13	9	173
Ambleside	20	6	9	15	4	12	19	9	14	18	15	8	149
Seathwaite	21	13	18	21	11	16	25	15	20	25	18	14	217
Stonethwaite	21	10	17	19	8	16	22	11	16	21	17	13	191

RAINFALL & EVAPORATION DURING TEN YEARS.

BOLTON LE MOORS, LANCASHIRE.

Latitude 53° 30′ N.; Height above Sea 320 feet.

	YEAR.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	October.	Nov.	Dec.	Total.
		In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
Rainfall.	1844	4.48	4.48	4.23	1.24	0.20	2.13	3.68	4.80	4.70	1.89	2.58	0.22	34.63
	1845	4.07	2.65	2.27	2.37	1.24	4.89	3.83	7.45	4.07	4.76	3.17	7.34	48.11
	1846	4.85	1.55	2.33	3.67	1.57	3.60	5.83	4.01	2.06	5.47	2.96	2.92	40.82
	1847	2.86	3.31	1.36	2.81	5.46	4.37	1.60	3.82	7.69	6.76	5.41	6.87	52.32
	1848	2.53	8.50	4.02	2.26	2.00	5.91	3.76	7.48	3.18	7.25	3.25	3.93	54.05
	1849	6.67	2.34	0.61	1.00	3.16	1.19	7.73	4.13	4.88	4.72	6.85	4.49	47.77
	1850	4.46	3.81	1.38	4.77	3.09	2.69	3.90	6.33	3.07	4.49	7.03	2.97	47.99
	1851	4.41	4.41	4.16	1.44	2.49	5.88	4.04	2.69	1.98	5.45	2.47	2.47	41.89
	1852	6.97	6.97	0.47	0.43	2.26	5.82	3.32	5.01	2.77	5.26	8.76	7.15	55.19
	1853	4.92	2.33	1.70	2.20	0.85	4.22	5.46	1.97	3.55	4.68	3.95	1.05	36.88
	Mean ...	4.63	4.03	2.25	2.22	2.23	4.07	4.32	4.77	3.79	5.07	4.64	3.94	45.96
Evaporation.	1844	0.45	0.83	1.57	1.94	5.50	2.27	3.29	2.20	2.16	1.17	1.02	0.20	22.60
	1845	0.52	0.61	1.83	2.76	3.15	3.98	3.81	2.44	2.02	1.30	0.59	0.38	23.39
	1846	0.62	0.58	1.17	1.98	4.48	5.34	4.28	2.63	1.46	1.17	0.30	0.15	24.16
	1847	0.25	0.51	1.80	2.02	3.46	3.72	3.77	2.76	1.66	1.36	0.83	0.62	22.76
	1848	0.24	1.41	1.37	2.26	4.06	3.11	2.91	2.59	1.52	1.62	0.46	0.47	22.02
	1849	0.50	0.41	1.04	2.19	4.29	4.32	4.24	3.41	2.98	1.41	1.13	0.39	26.21
	1850		1.73	1.54	3.09	4.21	4.13	4.61	4.40	2.65	1.14	1.29	0.44	29.23
	1851	1.05	1.05	1.90	2.18	4.51	3.26	4.55	3.05	1.96	1.63	0.63	0.63	26.40
	1852	1.66	1.66	2.31	4.64	4.65	4.77	5.86	4.29	2.22	1.64	1.26	0.96	35.93
	1853	1.12	0.69	1.34	2.89	5.47	3.48	2.89	2.84	1.59	0.49	0.55	0.50	23.85
	Mean ...	0.64	0.95	1.59	2.59	4.38	3.84	4.02	3.06	2.02	1.28	0.81	0.47	25.65

WHITEHAVEN, CUMBERLAND.

Latitude 54° 30′ N.; Height above Sea 90 feet.

	YEAR.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	October.	Nov.	Dec.	Total.
		In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In	In.	In.
Rainfall.	1844	4.1	3.5	3.7	2.7	0.3	3.9	4.2	2.0	5.8	4.3	1.9	0.3	36.7
	1845	4.5	2.8	3.7	2.6	1.5	4.1	3.0	7.0	3.7	6.7	4.0	5.6	49.2
	1846	4.6	2.0	4.5	2.8	2.3	2.3	9.1	4.1	2.8	8.0	4.7	1.9	49.1
	1847	1.9	1.8	1.4	2.6	3.4	2.9	0.8	4.5	3.7	5.4	7.9	6.6	42.9
	1848	3.7	7.8	4.6	0.5	1.8	3.9	3.6	5.0	2.3	5.8	3.5	4.8	47.3
	1849	5.7	2.0	0.8	1.5	3.0	1.2	5.5	3.8	2.8	5.2	5.0	2.4	38.9
	1850	3.0	4.8	1.0	3.1	1.3	2.0	5.3	4.5	2.6	3.4	6.3	3.1	40.4
	1851	9.4	3.8	3.4	2.3	1.1	3.9	3.5	4.1	2.7	4.7	2.5	1.7	43.1
	1852	8.0	3.5	0.3	1.2	4.2	3.5	2.9	5.2	2.1	3.0	5.1	11.0	50.0
	1853	5.9	2.3	1.2	2.5	0.3	3.1	4.9	3.1	2.7	6.6	4.3	0.5	37.4
	Mean ...	5.1	3.4	2.5	2.2	1.9	3.1	4.3	4.3	3.1	5.3	4.5	3.8	43.5
Evaporation.	1844	0.94	1.19	1.83	2.61	6.28	3.82	4.49	2.52	3.40	2.27	1.56	0.80	31.71
	1845	0.93	0.90	1.86	3.40	3.65	3.76	5.46	3.25	3.22	2.36	1.76	1.88	32.43
	1846	1.01	1.34	2.08	2.57	4.38	6.64	3.45	3.88	2.98	1.78	1.36	1.03	32.50
	1847	0.86	0.84	1.82	2.18	2.95	4.51	4.73	3.75	2.80	1.69	1.10	1.00	28.23
	1848	0.74	0.79	1.40	2.73	4.58	3.75	3.93	3.69	2.89	1.55	1.13	1.02	28.20
	1849	0.90	1.02	1.56	2.62	3.89	5.07	4.16	2.66	3.34	1.72	0.96	0.79	28.69
	1850	0.69	0.82	1.69	2.30	3.50	4.29	4.28	3.38	2.66	1.56	1.18	0.99	27.34
	1851	0.99	0.93	1.54	2.48	3.31	3.66	3.42	3.06	2.63	1.55	1.03	0.73	25.34
	1852	1.28	1.20	2.20	3.94	3.57	3.17	4.67	3.55	3.04	1.51	1.14	1.07	30.34
	1853	1.19	1.08	1.75	2.24	5.00	3.85	2.70	3.13	2.63	1.60	1.24	0.92	27.33
	Mean ...	0.95	1.01	1.77	2.71	4.11	4.25	4.13	3.29	2.96	1.76	1.25	1.02	29.21

MOUNTAIN RAINFALL.

LOCH KATRINE AND GORBALS DISTRICTS.

	LOCH KATRINE DISTRICT.						GLAS-GOW.	GORBALS DISTRICT.			
	Elevation 270 ft.	Elevation 1800 ft.	Elevation 380 ft.	Elevation 60 ft.	Elevation 1500 ft.	Elevation 1800 ft.	Elevation 20 ft.	Elevation 280 ft.	Elevation 310 ft.	Elevation 550 ft	Elevation 700 ft.
DATE.	At Bridge of Turk.	Between Glen Finglas and Benledi.	At Glengyle, head of Loch Katrine.	At the Inn at Aberfoyle.	On hills between Loch Ard and Loch Katrine. Ledard.	Benlomond, head of Duchray Valley.	At Throxholm, Mr. Gardner.	Wauk Glen Reservoir, No. 2.	Ryat Linn Reservoir, No. 1.	At Middleton.	At lack Loch.
1854.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	8.5	6.6	12.0	6.8	7.1	9.1	4.73	5.00	5.00	...	...
February ...	4.4	2.2	9.5	4.3	3.6	8.7	2.77	3.80	3.65	...	6.05
March	4.1	3.3	7.4	3.9	4.1	8.0	1.75	3.35	3.15	...	4.85
April	1.2	0.7	2.6	0.7	1.7	3.0	0.62	1.17	0.97	...	1.70
May	5.2	6.0	8.8	3.7	5.6	7.6	4.60	4.90	4.60	...	5.20
June.....	6.4	5.2	9.4	6.4	8.1	10.3	3.48	4.60	4.30	...	7.00
July	6.5	2.8	4.7	5.1	6.6	7.5	2.98	2.40	2.40	3.06	3.25
August	4.4	1.5	6.7	4.0	5.6	6.5	1.66	2.50	2.46	3.30	3.90
September ..	3.3	7.3	6.1	2.2	1.8	6.8	2.02	3.10	2.90	3.80	4.10
October	8.4	9.3	12.2	6.3	11.3	17.3	3.93	5.30	4.70	6.50	7.00
November ...	2.7	5.4	5.7	3.9	3.1	4.5	1.85	2.35	2.10	3.78	3.10
December ...	9.4	11.9	18.2	8.8	8.5	19.7	5.32	7.45	7.05	9.20	11.40
	64.5	61.9	103.3	56.1	67.1	109.0	35.71	45.92	43.28	29.64	57.55
1855.											
January	1.0	4.7	1.8	1.0	1.7	3.3	0.36	1.25	1.25	1.40	1.65
February ...	0.2	0.2	1.2	0.2	1.2	1.6	0.60	0.55	0.55	3.70	1.50
March	4.4	3.7	7.5	4.5		8.0	1.52	2.90	3.00		2.70
April	2.5	5.2	6.1	3.0		7.5	1.26	1.90	2.10	2.30	3.05
May	1.6	3.9	3.2	2.8		3.4	1.48	1.85	2.00	2.30	2.10
June.....	3.2	1.0	3.7	0.9		3.5	2.88	2.20	2.30	2.70	3.30
July	4.0	4.4	3.2	4.2		5.1	3.20	2.88	2.93	3.16	4.00
August	6.2	11.4	10.3	3.9		9.8	4.35	4.85	5.05	5.75	6.50
September ...	1.3	5.0	3.0	1.0		4.9	0.73	1.25	1.40	1.75	2.30
October	7.7	5.3	13.5	6.9		13.8	4.06	5.30	5.70	7.30	7.20
November ...	1.8	6.8	3.1	1.4		4.2	0.97	1.50	1.60	1.75	2.00
December ...	5.1	4.5	8.9	4.8		4.8	2.35	3.50	3.80	3.40	3.60
	39.0	56.1	65.5	34.6	...	69.9	23.76	29.93	31.68	35.50	39.90
1856.											
January	3.5		4.7	1.4	4.2	4.0	2.00	2.70	2.80	2.85	3.00
February ...	7.7		10.8	7.3	9.0	13.2	3.31	5.00	5.30	4.60	6.20
March	0.1		0.7	0.2	0.1	0.9	0.05	0.00	0.00	0.00	0.00
April	2.7		4.7	2.9	3.5	4.0	1.46	2.00	2.15	2.15	2.00
May	3.2		4.6	3.8	4.5	5.7	2.80	3.35	3.35	3.75	4.20
June.....	5.6		9.9	4.7	12.3	10.0	3.40	5.70	5.75	6.30	7.95
July	3.8		9.1	3.1	6.2	4.5	1.80	2.75	2.80	3.25	3.90
August	5.2		6.3	3.9	9.7	8.8	2.40	4.50	4.55	5.30	5.40
September ...	4.4		5.5	3.7	5.6	6.5	2.40	3.10	3.10	3.10	4.20
October	3.9		7.2	1.8	6.2	6.9	1.20	1.85	1.85	2.15	3.00
November ...	1.5		4.4	0.1	3.9	6.8	0.80	1.25	1.55	2.50	2.60
December ...	6.7		11.4	3.8	8.9	9.7	3.85	5.80	6.55	6.30	9.05
	48.3	...	79.3	36.7	74.1	81.0	25.47	38.00	39.75	42.25	51.50

Gauging discontinued.

Gauge kept very irregularly, and stopped in have been interfered with.

MOUNTAIN RAINFALL.

LOCH KATRINE AND GORBALS DISTRICTS.

DATE.	LOCH KATRINE DISTRICT. Elevation 270 ft.	Elevation 1800 ft.	Elevation 380 ft.	Elevation 60 ft.	Elevation 1500 ft.	Elevation 1800 ft.	GLASGOW. Elevation 20 ft.	GORBALS DISTRICT. Elevation 280 ft.	Elevation 310 ft.	Elevation 530 ft.	Elevation 700 ft.
1857.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	6.3	3.2	12.0	1.2	4.9	7.5	1.65	3.30	3.84	3.80	4.95
February	4.6	3.3	10.5	8.5	6.5	7.7	0.90	2.25	2.60	2.75	3.10
March	5.3	3.1	7.3	3.4	4.9	6.0	1.95	2.75	3.05	3.60	3.50
April	3.7	4.6	7.8	4.6	5.2	5.4	1.70	1.70	1.85	2.20	2.65
May	3.3	3.8	6.0	4.8	5.9	5.9	1.55	1.90	1.90	1.95	2.05
June	2.5	3.8	4.0	1.4	3.8	3.9	2.85	3.35	3.10	3.95	4.00
July	3.1	3.5	5.2	1.0	4.6	5.1	1.22	1.50	1.55	2.45	2.95
August	2.9	4.4	4.2	3.1	4.7	4.9	1.40	1.45	1.45	1.90	1.50
September	4.2	3.7	4.0	4.4	5.4	6.4	2.96	2.55	2.60	3.30	3.00
October	5.3	5.6	7.7	5.6	7.4	8.8	2.70	3.60	3.80	4.75	5.80
November	3.9	3.8	5.9	2.7	8.0	5.9	2.54	3.20	3.30	3.80	4.20
December	9.7	5.5	17.0	6.9	12.9	18.0	3.94	6.70	6.80	7.25	8.00
	54.8	48.3	91.6	47.6	74.2	85.5	25.36	34.25	35.84	41.70	45.70
1858.											
January	7.2	4.7	9.0	5.5	12.6	12.4	3.26	4.75	5.00	6.10	5.80
February	0.9	0.0	2.5	1.1	1.8	3.3	1.30	2.00	2.15	1.80	1.10
March	2.2	0.8	3.3	1.1	2.9	1.9	1.46	1.95	1.95	5.70	4.20
April	3.6	3.5	5.5	0.6	5.6	3.9	2.12	2.38	2.45		3.15
May	5.5	5.5	8.2	2.4	9.0	7.5	3.58	5.25	5.35	5.70	7.00
June	4.4	4.5	6.4	4.4	7.2	6.6	3.79	3.20	3.20	3.20	3.70
July	6.9	8.5	7.8	2.8	9.3	7.6	5.39	4.95	5.05	5.30	5.50
August	4.6	4.9	7.3	2.1	8.9	7.4	2.09	2.45	2.50	3.40	4.50
September	5.3	5.5	8.2	3.9	9.0	10.2	2.88	3.55	3.65	4.80	Gauging discontinued.
October	6.6	6.6	9.7	6.7	12.2	11.0	5.09	6.45	6.75	7.55	
November	3.3	3.3	3.8	2.5	6.4	4.2	1.63	1.85	1.85	2.60	
December	9.7	7.4	13.1	8.4	12.2	14.4	3.08	4.55	4.65	5.55	
	60.2	55.2	84.8	41.5	97.1	90.4	35.67	43.33	44.55	51.70	34.95
1859.											
January	10.1	6.1	14.3	8.5	10.0	14.0	4.43	6.50	7.05	6.00	Gauging discontinued.
February	6.4	3.8	11.0	5.2	7.6	11.0	5.23	6.25	7.60	5.50	
March	9.2	4.6	14.5	5.9	11.2	14.9	5.60	6.65	7.75	9.70	
April	4.9	3.1	5.5	3.7	5.0	3.9	3.90	4.20	4.50	5.25	
May	0.4	0.5	0.3	0.3	0.7	0.7	0.52	0.35	0.40	0.50	
June	1.3	0.5	2.9	1.4	3.2	3.5	1.36	1.65	1.80	2.05	
July	2.0	3.6	4.6	2.5	6.1	5.5	1.98	3.00	3.00	4.00	
August	5.4	6.1	7.9	5.6	10.1	9.8	2.89	4.15	4.30	4.55	
September	9.4	8.4	10.5	6.5	13.2	13.2	3.88	4.65	4.90	6.70	
October	4.4	3.6	5.6	3.5	6.6	5.2	3.46	3.70	3.85	3.60	
November	6.8	5.5	9.0	5.5	6.3	7.5	3.04	3.85	3.85	4.50	
December	4.9	2.2	7.6	4.0	5.3	2.6	3.50	3.75	4.35	5.30	
	65.2	48.0	93.7	52.6	85.3	91.8	39.79	48.70	53.35	57.65	
1860.											
January	8.5	6.2	10.5	5.2	3.4	9.5	5.09	5.55	5.95	5.65	Gauging discontinued.
February	4.1	2.4	14.5	1.8	2.1	0.0	3.21	4.55	4.70	4.40	
March	6.2	1.1	11.2	4.4	1.5	12.7	7.94	3.80	4.50	4.50	
April	1.9	3.1	2.8	0.2	2.0	2.0	1.01	1.30	1.40	1.35	
May	3.7	3.2	6.2	3.4	5.5	8.0	...	2.55	2.70	3.55	
June	8.1	8.5	9.4	6.8	14.0	11.0	4.78	3.95	3.95	4.40	
July	3.2	5.7	2.1	0.4	4.0	4.4	2.13	2.35	2.40	2.72	
August	5.2	6.2	7.5	3.8	9.4	10.4	3.54	3.35	3.55	4.05	
September	3.3	2.3	5.8	3.2	6.4	5.6	1.50	1.90	2.00	2.25	
October	8.0	5.7	14.1	6.2	10.5	14.7	4.68	6.00	6.10	6.82	
November	2.9	2.7	4.3	2.1	6.4	3.6	1.28	1.55	1.65	2.73	
December	4.7	6.7	5.8	2.9	8.3	1.6	2.80	2.60	2.60	2.30	
	59.8	53.8	94.2	40.4	73.5	83.5	...	39.45	41.50	44.72	...
Mean	56.0	53.9	87.5	44.2	78.5	87.3	30.96	39.94	41.42	45.59	45.70

RAINFALL OF INDIA.

COMPARATIVE MONTHLY FALL AT BOMBAY, THE GHÂTS, AND THE DECCAN.

	Bombay.		Ghâts.			Western Districts.—1848.							Eastern Districts.—1848.				
			Mahabuleshwur.					Sattarah.									
	1848.	Means of 33 years.	Sanitarium, Means 14 years.	Sindola, 1848.	Sanitarium, 1848.	Meera.	Enteshwar.	Hill Fort.	Town.	Cantonment.	Bhore.	Wye.	Phultun.	Jhutt.	Bijapoor.	Punderpoor.	Ahalkote.
	Hghs. in ft. above Sea.	20	4,500	4,600	4,500	2,340	3,700	3,200	2,320	2,320	2,350	2,320	2,000	2,000	2,000	2,000	2,000
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
April	0.58	...	1.31	...	...	...	...	...	0.74	0.76	...	...	...	...	...	...	...
May	5.67	...	3.31	3.60	3.69	2.75	2.60	2.50	3.04	2.79	2.10	2.09	6.24	...	...	0.75	1.83
June	42.37	22.26	46.53	41.70	58.22	10.93	5.98	4.10	3.71	3.26	2.37	2.20	4.30	1.59	0.80	2.02	3.68
July.....	13.83	25.04	92.10	74.28	96.28	22.90	19.83	18.77	14.64	12.02	13.20	9.05	2.70	3.07	3.67	4.38	4.65
August ...	7.87	17.08	72.33	47.81	63.95	6.16	6.02	5.00	2.60	2.55	5.19	1.61	1.24	4.82	8.52	6.21	4.83
Sept.	4.01	11.25	31.32	6.17	9.48	2.30	1.80	1.46	2.14	1.40	0.91	0.96	3.66	2.64	4.01	4.35	2.84
Oct.....	5.34	1.19	4.58	7.23	9.31	2.75	2.27	4.64	4.89	3.28	1.50	2.75	2.45	3.88	4.64	8.35	5.32
Nov.	...	...	2.07	4.37	4.08	1.85	0.19	2.91	1.57	1.71	4.15	2.25	3.59	2.17	3.78	2.49	2.30
Total ...	79.67	76.82	254.05	185.16	192.61	49.64	38.69	39.38	33.41	27.81	29.42	20.73	24.18	18.17	25.42	28.55	25.45

COMPARISON OF FALL AT BOMBAY AND MAHABULESHWUR.

Bombay 20 feet, Mahabuleshwur 4,500 feet above the Sea, and 130 miles inland.

	Bombay.						Mahabuleshwr		Bombay.						Mahabuleshwr		Bombay.						Mahabuleshwr
Year	June.	July.	Aug.	Sept.	Oct.	Total.	Total.	Year	June.	July.	Aug.	Sept.	Oct.	Total.	Total.	Year	June.	July.	Aug.	Sept.	Oct.	Total.	Total.
1829	27.86	19.78	12.40	4.95	0.66	65.65	257.06	1836	21.36	24.53	37.41	4.69	0.00	87.99	243.56	1843	9.33	22.49	18.20	9.00	0.25	59.27	285.67
1830	20.96	32.46	10.66	7.78	0.00	71.86	232.93	1837	12.61	24.39	22.43	5.15	0.00	64.58	207.76	1844	14.17	35.52	6.55	9.16	0.00	65.40	262.32
1831	22.46	27.31	27.64	22.34	2.08	101.83	185.82	1838	29.70	8.70	7.34	5.04	0.00	50.78	180.17	1845	19.70	20.44	6.50	8.03	0.00	54.73	249.93
1832	13.03	48.05	4.65	7.11	0.65	74.09	226.87	1839	18.28	32.19	18.45	4.70	0.00	73.62	233.23	1845	31.71	40.56	5.60	8.45	1.16	87.48	288.34
1833	12.50	21.80	13.35	23.54	0.20	71.39	203.74	1840	25.04	24.24	4.20	7.55	2.12	63.15	284.43	1847	35.47	16.80	8.92	5.80	0.32	67.31	218.83
1834	14.16	21.83	18.05	12.55	3.88	70.47	197.31	1841	25.27	21.21	20.53	1.27	3.21	71.49	281.04	1848	42.37	13.83	7.87	4.01	5.34	73.42	245.01
1835	9.95	4.27	35.76	12.17	0.42	62.61	226.71	1842	16.84	26.45	37.10	10.41	4.36	95.16	304.90	1849	22.82	51.68	13.66	29.65	1.07	118.88	338.38

During the months not mentioned above, there was either no Rainfall, or so little as to be practically unimportant.

RAINFALL OF INDIA.—BOMBAY PRESIDENCY.

DETAILS OF MONTHLY FALL.

Period.		Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	October.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Palemcottah Height 200 ft.	1842	1.20	0.19	1.05	0.45	0.55	0.02	0.01	0.03	2.50	6.60	9.62	0.95	23.12
	1843	4.02	2.50	0.77	1.20	5.65	0.00	0.00	0.00	0.00	7.15	1.65	3.95	26.90
	1844	0.20	0.55	0.00	0.75	0.10	1.17	0.05	0.00	1.75	2.65	1.70	2.76	11.68
	1845	0.43	0.00	5.27	0.55	1.62	0.15	0.00	0.00	0.65	6.17	2.02	8.75	25.63
	1846	0.80	1.35	0.57	2.30	4.05	0.07	0.07	0.00	0.30	1.80	5.97	0.65	17.75
	Mean	1.33	0.92	1.53	1.05	2.39	0.28	0.03	0.00	1.05	4.87	4.19	3.41	21.02
Shenkottah. Height 600 or 700 feet.	1842	1.20	1.30	0.00	2.05	3.90	5.65	2.80	3.40	3.10	3.20	14.85	0.00	39.45
	1843	4.15	0.80	2.45	4.15	11.20	4.80	6.20	1.05	1.15	7.15	1.50	3.50	48.10
	1844	0.00	0.00	2.40	0.00	0.50	3.60	0.00	1.80	1.60	6.25	4.25	3.70	24.10
	1845	2.00	0.00	4.40	2.20	0.00	3.80	4.65	0.35	0.00	15.40	4.05	5.85	42.70
	1846	0.57	0.00	0.70	4.65	6.20	8.60	3.40	1.10	2.50	5.95	4.47	3.45	41.60
	Mean	1.58	0.42	1.99	2.61	4.36	5.29	3.41	1.14	1.67	7.59	5.82	3.30	39.19
Cape Comorin. Height 60 ft.	1843	0.90	0.00	0.00	0.00	6.50	0.80	0.95	0.00	0.65	4.80	0.00	4.60	19.20
	1844	0.00	0.00	0.00	0.00	1.20	3.00	0.00	0.00	1.00	7.50	4.60	2.20	19.50
	1845	0.20	0.00	0.90	0.00	1.30	2.20	0.70	0.00	0.00	10.70	1.40	Heavy Shwrs.	18.00
	1846	0.00	0.00	2.80	3.30	9.40	12.25	1.20	1.45	0.00	12.10	9.82	4.40	56.72
	Mean	0.27	0.00	0.92	0.75	4.55	4.56	0.71	0.36	0.41	8.77	3.95	2.80	28.35
Vaurioor. Height 60 ft.	1842	0.35	0.65	0.00	0.00	2.25	1.20	0.00	0.40	1.82	4.35	9.25	0.00	20.27
	1843	1.40	1.00	0.75	0.40	9.90	2.05	0.80	0.10	0.35	4.15	0.45	4.40	25.75
	1844	0.00	0.50	0.20	0.00	0.90	3.00	0.80	0.00	0.15	7.45	3.70	1.35	18.05
	1845	2.75	0.00	3.65	0.00	1.70	1.45	2.70	0.00	0.35	12.92	2.40	8.90	36.82
	1846	0.00	0.00	0.90	1.65	5.20	2.90	0.55	0.00	0.00	4.00	5.50	1.75	22.45
	Mean	0.90	0.43	1.10	0.41	3.99	2.12	0.97	0.10	0.53	6.57	4.26	3.28	24.67
Cochin. Height 20 ft.	1842	0.00	0.00	0.00	3.05	25.07	25.05	13.70	21.95	10.15	3.55	3.65	0.00	105.27
	1843	5.15	0.00	2.00	4.50	27.15	37.32	21.05	4.27	7.75	9.45	0.10	5.75	124.49
	1844	0.00	0.45	1.70	1.70	19.35	22.42	19.10	11.75	2.37	17.55	4.50	1.07	101.97
	1845	3.42	...	5.80	2.20	3.57	31.37	16.10	11.22	1.67	11.85	0.92	4.45	92.60
	1846	0.02	...	0.70	4.80	19.70	37.32	16.72	16.27	2.15	5.95	2.25	0.10	106.00
	Mean	1.72	0.09	2.04	3.25	18.97	30.69	17.33	13.09	4.82	9.67	2.28	2.27	106.06
Quilon. Height 80 ft.	1842	0.00	1.17	1.32	3.30	22.24	16.00	8.65	8.60	7.42	4.87	7.47	0.00	81.06
	1843	1.42	0.47	0.50	9.85	24.62	26.52	20.72	7.45	5.15	5.85	2.15	1.00	105.72
	1844	0.00	0.00	0.55	0.70	8.15	15.55	5.75	6.70	2.37	13.95	3.25	3.60	60.57
	1845	3.30	0.00	4.65	0.25	4.85	13.80	9.55	3.95	0.45	15.35	1.85	3.70	61.70
	Mean	1.18	0.41	1.75	3.52	14.97	17.97	11.17	6.67	3.85	10.01	3.68	2.07	77.26
Alleppy. Height 30 ft.	1842	1.15	0.25	2.92	2.50	27.67	20.00	10.60	12.30	7.57	12.95	6.50	0.10	104.52
	1843	3.20	0.75	6.90	5.75	30.12	32.80	21.57	5.22	9.72	9.12	0.90	5.77	131.85
	1844	0.37	2.87	2.55	3.00	24.33	23.12	16.60	10.42	4.92	15.37	9.90	5.40	118.70
	1845	4.92	0.50	8.80	2.65	17.80	25.20	11.92	6.47	1.00	9.67	4.35	4.50	97.80
	1846	0.00	1.70	0.20	3.15	31.45	29.00	12.45	12.27	3.42	13.00	5.77	1.00	113.43
	Mean	1.93	1.21	4.27	3.41	26.27	26.02	14.63	9.33	5.32	12.02	5.48	3.35	113.26
Trevaudrum Height 130 ft.	1842	3.70	0.35	0.85	3.60	13.70	9.50	4.25	3.75	6.30	3.05	8.30	0.35	57.70
	1843	0.80	0.02	2.52	8.80	17.12	16.62	12.90	2.55	3.10	7.52	2.05	11.42	85.45
	1844	0.00	0.00	0.10	0.30	4.55	6.15	3.80	5.67	3.75	15.17	4.40	2.15	47.05
	1845	4.40	0.77	3.40	0.85	4.55	15.80	4.30	0.90	0.15	18.52	3.92	5.00	62.57
	1846	0.10	0.00	1.07	4.02	11.42	17.75	6.92	3.67	0.75	17.50	4.40	2.30	69.92
	Mean	1.80	0.23	1.79	3.51	10.27	13.16	6.53	3.31	2.81	12.35	4.61	4.24	64.54
Poona. Hght 1823 ft.	1826	0.00	0.00	0.00	0.00	3.41	3.30	8.43	1.03	1.54	1.90	2.33	0.40	22.34
	1827	2.29	0.00	0.40	0.00	0.04	13.47	1.79	2.01	4.51	4.33	0.15	0.00	28.99
	1828	0.00	0.00	0.00	0.00	1.95	1.63	7.58	3.25	6.92	6.34	2.04	0.00	29.81
	1829	0.00	0.00	0.00	0.00	2.74	4.86	4.38	3.21	0.33	1.81	0.00	1.20	18.53
	1830	0.00	0.00	0.00	1.04	0.79	5.57	5.35	1.72	0.29	3.07	0.00	0.00	17.83
	Mean	0.46	0.00	0.08	0.21	1.79	5.77	5.51	2.24	2.72	3.49	0.90	0.32	23.50

RAINFALL OF INDIA.

DETAILS OF MONTHLY FALL.

Period.		Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Calcutta. Lat. 22° 33' N.; Height 18 feet.	1839	1.34	0.23	0.31	1.31	7.84	9.12	14.77	9.45	18.95	0.59	1.06	0.00	64.97
	1840	0.00	0.00	0.44	0.80	8.05	13.05	9.01	21.31	4.94	1.81	0.00	0.00	59.41
	1841	0.85	0.24	0.76	3.26	5.31	7.03	14.09	13.96	11.59	3.16	0.00	0.00	60.25
	1842	0.00	0.00	3.76	3.73	1.82	26.24	9.61	21.96	4.08	3.96	0.19	0.76	76.11
	1843	1.67	0.64	1.20	2.42	5.33	8.64	10.18	20.05	11.19	2.16	0.00	0.86	64.34
	1844	0.22	0.08	0.22	3.13	7.44	12.13	13.72	26.91	5.02	4.99	0.00	0.00	73.86
	1845	1.10	0.64	1.17	7.30	2.58	10.66	12.80	15.36	4.80	5.86	0.00	0.81	63.08
	1846	0.82	1.80	2.30	0.57	2.49	12.14	20.07	13.26	9.97	10.76	0.74	1.52	76.44
	1847	0.00	0.00	0.00	2.33	4.75	12.01	15.69	15.09	10.95	5.86	5.59	0.05	72.36
	1848	0.00	0.00	0.41	1.31	6.22	13.52	17.50	9.22	4.74	5.41	0.20	0.16	58.69
	1849	2.44	1.67	2.16	0.32	7.44	14.40	12.24	10.11	14.71	...	...	...	65.49
	1850	0.00	2.00	1.52	0.28	3.30	11.99	15.34	14.88	20.59	3.61	1.76	0.00	75.27
	1851	0.07	2.41	1.05	3.75	0.08	8.39	12.89	10.78	8.49	16.25	0.00	0.00	64.16
	1852	1.58	0.00	6.08	1.84	11.89	8.59	9.95	17.98	20.41	2.59	0.00	0.50	81.41
	1853	0.10	0.00	0.00	1.00	2.42	8.27	12.76	13.44	9.15	4.94	0.00	0.00	52.08
	1854	0.00	1.01	1.28	7.25	3.75	16.82	10.60	11.59	9.26	4.01	0.90	0.00	66.47
	1855	0.46	1.11	0.14	3.83	5.97	5.84	19.18	11.07	19.39	3.38	0.00	0.00	70.37
	1856	1.06	0.00	2.23	0.62	8.18	12.67	10.94	10.30	9.02	9.21	0.00	0.00	64.23
	1857	0.00	0.00	0.96	1.80	9.33	10.30	12.98	18.70	13.30	1.60	0.00	0.00	68.97
	1858	0.07	0.54	0.22	0.97	3.26	8.22	17.96	14.65	4.74	8.03	0.00	1.08	59.76
	Mean	0.59	0.62	1.31	2.39	5.38	11.50	13.61	15.00	10.77	4.90	0.52	0.29	66.89
Madras. Lat. 13° 5' N.; Height 30 feet.	1841	0.06	0.00	0.00	0.41	4.34	3.91	1.56	8.79	4.21	22.09	6.43	1.17	52.98
	1842	1.76	0.00	0.25	0.00	0.37	1.51	3.42	3.07	5.56	7.99	12.32	0.19	36.44
	1843	6.40	0.03	0.79	0.04	14.07	1.93	1.39	2.20	4.14	6.25	5.27	7.25	49.76
	1844	0.67	0.49	0.00	0.00	2.70	2.66	3.22	2.66	12.42	13.50	3.67	2.32	44.31
	1845	1.51	0.00	0.04	0.04	1.51	2.36	2.90	2.01	4.09	3.36	5.12	15.33	38.27
	1846	2.94	0.23	0.00	0.00	1.34	3.71	9.12	5.34	0.92	30.58	19.39	6.89	80.47
	1847	0.00	0.22	0.00	0.45	0.73	3.79	3.09	9.71	5.87	16.31	18.66	22.16	80.99
	1848	0.00	0.00	0.00	6.38	0.10	1.86	3.87	5.13	3.09	13.93	17.28	3.11	54.75
	1849	2.50	0.00	0.00	1.12	0.04	3.90	3.58	4.89	1.65	9.19	6.14	6.81	39.81
	1850	0.04	4.27	0.00	0.98	2.94	2.92	1.53	3.06	3.04	4.32	8.12	5.66	36.88
	1851	0.00	0.00	2.62	0.00	2.22	1.88	7.99	2.26	6.78	20.60	19.40	8.92	72.67
	1852	2.25	0.00	3.37	0.77	0.00	0.62	4.14	1.38	2.23	9.07	12.25	0.00	36.08
	1853	0.42	0.30	0.09	0.00	0.00	1.15	4.29	7.05	6.37	10.22	9.29	4.02	43.20
	1854	0.94	0.68	0.26	0.07	...	1.12	2.54	1.65	3.75	10.62	1.47	9.09	32.19
	1855	...	0.03	...	0.01	5.51	0.82	3.32	5.66	0.86	3.88	9.71	9.71	39.51
	1856	0.32	0.00	0.10	0.12	0.06	2.94	2.27	1.05	1.40	37.73	5.82	0.99	52.80
	1857	0.00	0.02	0.00	0.83	3.03	1.63	3.08	2.11	3.61	12.07	22.12	...	48.50
	1858	1.17	0.37	0.44	0.71	2.28	2.26	3.60	4.00	4.20	13.63	10.74	6.10	49.50
	Mean													
Patna.	1842-3	0.11	0.23	0.10	0.12	0.00	7.33	14.06	11.86	10.11	6.46	0.00	1.74	52.12
	1843-4	0.46	1.53	0.07	1.19	1.54	5.50	3.05	3.76	3.38	4.03	...	...	24.51
	1844-5	0.67	0.75	0.00	0.05	3.40	4.95	9.00	10.78	4.26	...	0.00	0.00	33.86
	1845-6	0.14	0.75	0.60	0.00	2.24	4.74	9.34	7.20	7.69	0.00	0.00	0.60	33.30
	1846-7	1.90	0.07	0.05	0.64	0.84	6.56	10.42	9.00	9.12	0.85	0.00	0.00	39.45
	Mean...	0.65	0.67	0.16	0.40	1.60	5.81	9.16	8.52	6.91	2.27	0.00	0.47	36.65
Peninsular Ghauts. Poda: Uttray betta, 8,640 ft. Mercara. Mullay 4,800 ft. Coorg 4,800 ft.	Mean													
	1838		0.45	1.51	2.60	7.37	30.40	55.88	27.00	11.91	4.60	1.38	0.25	143.35
	1840													
	1845	8.40	0.15	14.20	1.37	22.68	52.15	50.15	25.57	8.08	70.70	16.10	21.00	290.55
	1846	4.65	0.45	0.73	9.60	36.50	51.05	33.32	21.12	7.33	38.25	21.67	10.20	235.87
	1847													
	1848	0.12	7.43	3.61	19.80	4.86	4.55	7.45	9.32	7.52	12.49	11.85	12.28	101.28
Himalaya. D'rjeeling 6,902 ft.	1851	2.05	2.75	4.40	0.55	6.75	31.00	27.15	16.70	19.60	9.35	1.50	0.05	121.85
	1852	3.45	2.40	4.00	4.55	9.15	17.30	35.40	15.35	15.15	0.45	0.05	0.80	108.05
	1853	0.00	0.75	17.40	2.70	2.07	16.90	29.49	31.26	20.15	4.34	0.37	0.00	135.43
	1854	1.85	0.75	0.00	1.00	5.68	40.57	18.55	40.91	28.10	4.15	2.10	0.20	143.86
	Mean	1.84	1.66	6.45	2.20	5.91	28.94	27.65	26.06	20.75	4.57	1.01	0.26	127.30

RAINFALL OF THE COLONIES.

NOTE.—The year 1853 for Bahamas, *et seq.*, contains the months from February to December for 1853, and January, 1854.

Period.		Jan.	Feb	Mar	Apr	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Moulmein.	1839	0.00	0.00	0.00	2.87	23.61	35.69	56.82	24.32	23.20	13.18	1.50	0.00	181.19
	1840	0.00	0.00	0.00	1.90	19.61	30.10	54.79	46.91	16.10	12.90	2.10	0.00	184.41
	1841	0.00	0.15	0.00	0.00	18.40	44.80	57.80	26.55	20.40	2.21	0.80	1.95	173.06
	1842	0.00	0.30	0.00	0.80	11.10	52.50	55.10	24.60	40.20	6.60	1.00	0.00	192.10
	1843	0.00	0.00	0.00	0.00	13.40	32.10	34.45	39.10	26.97	2.00	0.50	1.60	150.12
	Mn. of 13 yrs.	0.00	0.03	0.23	1.14	17.52	34.39	41.85	37.46	28.74	7.58	2.43	0.36	189.68
Penang.	1833	0.90	3.85	1.95	5.45	3.25	9.75	3.90	6.30	6.17	10.65	5.12	5.02	62.31
	1834	5.92	2.40	6.10	6.60	7.50	4.80	6.77	10.80	12.95	13.45	9.02	3.42	89.73
	1835	4.85	2.85	9.77	6.12	5.05	6.60	12.47	9.07	8.10	11.12	14.97	3.45	94.52
	1836	1.70	1.25	3.30	10.52	2.17	8.60	4.27	14.85	11.80	14.25	6.12	4.91	83.74
	Mean	3.34	2.59	5.28	7.20	4.49	7.44	6.85	10.25	9.75	12.37	8.81	4.20	82.58
Malacca	1828	10.00	7.92	9.80	4.35	6.85	4.00	...	8.70	12.50	9.00	7.75	9.28	90.15
Singapore.	1841	8.75	6.75	4.87	3.22	6.95	8.09	7.33	7.29	4.20	4.13	12.65	6.35	80.58
	1842	5.14	10.94	7.17	11.33	9.15	5.86	5.98	6.25	4.25	21.19	9.60	4.35	101.21
	1843	17.80	3.05	9.67	5.66	9.01	2.27	8.50	5.66	4.98	12.53	9.81	4.25	93.19
	Mean	10.56	6.91	7.23	5.74	8.37	5.41	7.27	6.40	4.48	12.62	10.69	4.98	91.66
Cape Town.	1849	0.25	0.46	0.49	0.58	6.73	3.50	4.32	2.99	2.31	0.60	0.93	1.44	24.60
	1850	2.07	0.19	1.59	4.37	2.38	6.40	4.46	3.59	2.69	3.43	1.86	0.41	33.44
	1851	0.19	0.03	0.15	0.98	2.99	6.82	3.85	0.59	1.40	2.10	0.57	0.60	20.27
	1852	0.31	0.51	1.65	1.26	4.81	1.71	3.71	4.52	2.40	0.78	1.16	0.34	23.18
	1853	1.19	0.40	2.12	1.12	2.58	3.98	4.06	2.72	1.46	1.32	0.08	0.17	21.20
	1854	0.32	0.53	1.25	1.13	2.30	2.99	2.82	3.36	2.85	1.28	0.83	0.37	20.03
	1855	0.37	0.17	1.03	1.80	3.10	4.47	2.70	5.24	4.88	0.65	0.12	0.01	24.54
	Mn. of 14 yrs.	0.88	0.65	0.85	1.85	3.58	4.31	2.92	3.32	2.33	1.01	1.09	0.52	23.31
Hobart Town.	1841	0.03	3.10	0.33	1.11	0.53	1.23	1.01	1.32	0.82	2.41	1.75	0.31	13.95
	1842	1.83	1.05	0.07	0.89	2.09	4.41	3.46	0.99	1.08	1.78	5.84	0.11	23.60
	1843	0.55	0.11	0.02	1.96	0.10	1.91	2.97	1.09	0.99	1.47	1.70	0.56	13.43
	1844	2.01	0.34	3.22	0.92	2.24	2.74	2.12	1.16	7.14	2.57	1.56	0.23	26.25
	1845	0.58	1.91	1.55	0.24	0.72	4.27	0.72	0.63	0.73	1.19	3.75	0.39	16.68
	1846	1.38	2.64	2.15	2.68	0.65	2.29	2.20	1.53	0.82	1.61	2.87	1.14	21.96
	1847	0.73	0.07	2.67	1.74	1.49	0.56	1.73	0.60	0.39	1.74	2.21	0.53	14.46
	1848	1.04	0.79	1.18	0.51	4.38	1.12	2.43	2.66	1.84	1.27	4.04	2.36	23.62
	1849	0.74	1.02	2.37	1.44	3.82	2.25	5.98	2.75	1.91	1.42	8.92	0.90	33.52
	1850	1.20	1.10	0.29	2.19	0.57	0.70	0.30	1.31	1.67	1.26	4.31	0.61	14.51
	1851	2.33	0.58	0.73	0.18	0.74	2.35	1.17	1.10	2.16	0.79	4.19	1.66	17.98
	1852	1.46	0.19	0.31	4.99	1.46	0.22	3.14	3.47	3.19	1.77	1.41	2.01	23.62
	Mean	1.17	1.07	1.24	1.57	1.57	2.00	2.27	1.55	1.89	1.52	3.55	0.90	20.30
Lanceston } Tasmania }	1847	1.09	0.07	4.49	3.46	2.67	5.11	5.62	2.47	1.23	2.21	1.97	1.20	31.59
	1848	2.34	0.73	2.21	0.85	5.43	2.27	2.79	3.29	4.04	4.28	4.51	2.68	35.41
Geelong } S. Astrlia }	1849	0.43	1.15	1.47	3.03	1.08	2.44	2.94	3.77	2.08	1.36	2.93	0.81	23.49
	1850	1.50	0.49	0.35	1.75	1.09	2.97	1.00	1.14	2.91	0.33	1.29	1.31	16.13
Adelaide } S. Astrlia }	1854	0.09	0.01	0.73	3.55	1.53	1.16	2.54	2.78	1.27	1.73	...	...	...
Mean		0.58	0.57	0.68	1.94	2.57	3.43	2.98	3.12	2.33	1.60	1.58	1.29	22.72
Max. Mth. 14 yrs		4.00	2.32	1.61	6.73	6.34	7.30	5.04	6.24	4.64	2.88	3.55	3.82	...
Bahamas	1853	0.91	0.50	0.58	2.54	0.76	8 02	...	8.31	10.81	5.91	2.64	1.21	42.19
Jamaica	,,	0.72	1.27	0.16	1.89	4.75	3 81	1.40	8.10	0.96	1.35	7.01	2.89	34.31
Barbadoes	,,	1.19	4.34	2.10	1.11	13.41	3.36	3.00	5.13	7.55	8.59	9.23	9.23	68.24
Gibraltar	,,	5.08	10.49	2.51	1.32	6.48	0.07	0.00	0.01	1.24	2.59	5.56	11.94	47.29
Malta	,,	5.08	4.96	0.87	0.21	0.10	0.00	0.00	0.00	1.15	2.22	9.93	3.55	28.07
Corfu	,,	9.16	7.64	...	...	...	0.72	0.05	0.21	13.63	0.15	5.99	16.74	54.29
Mauritius	,,	4.12	5.80	4.54	5.96	6.75	8.14	0.79	0.98	0.68	0.48	0.68	0.58	39.52
Columbo	,,	5.35	2.47	2.22	10.62	25.45	1.99	4.20	0.47	0.81	6.41	9.01	2.62	71.63
Hong Kong	,,	0.09	0.88	0.31	1.15	5.95	9.23	28.65	0.58	18.54	2.27	10.59	3.12	81.35
Fremantle A.	,,	0.00	1.14	0.45	3.38	4.15	4.57	11.30	3.69	4.38	0.05	0.62	0.21	33.94
AucklndN.Z.	,,	0.16	4.98	7.84	5.57	4.30	5.67	4.94	2.34	6.94	1.93	2.25	1.50	48.42

BRITISH RAINFALL AND EVAPORATION.

LITTLE BRIDY, DORSET.

Latitude 50° 41′ North; Longitude 2° 48′ West; Height above Sea 348 feet; Surface of evaporating dish 4 inches above ground.

Rainfall.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
1858	1.66	2.81	1.61	4.27	2.79	1.14	3.93	3.28	3.17	2.96	3.37	5.42
1859	2.71	3.66	2.68	3.52	1.17	1.03	2.61	3.13	4.55	5.20	4.43	4.29
1860	5.42	1.62	3.32	3.04	4.36	7.47	2.57	5.32	3.64	2.00	3.94	6.13
Mean	3.30	2.69	2.54	3.61	2.77	3.21	3.04	3.91	3.79	3.39	3.91	5.28
Mean Daily	.106	.096	.082	.120	.089	.107	.098	.123	.126	.109	.130	.170

Greatest Fall of Rain in 24 Hours.

1858	0.32	0.79	0.34	1.03	0.74	0.60	2.06	0.89	0.93	0.52	0.68	0.97
1859	0.52	0.82	0.64	0.80	0.17	0.27	0.64	0.62	0.74	1.16	0.76	1.09
1860	0.83	0.48	0.47	0.82	0.92	1.05	0.59	0.79	0.64	0.51	0.75	1.49

Number of Days on which Rain Fell.

1858	16	13	16	14	16	6	13	13	18	16	14	23
1859	19	16	17	18	13	12	10	11	20	20	14	17
1860	26	13	28	18	15	26	14	25	18	17	16	17

Monthly Evaporation.

1858	0.72	1.02	1.31	2.91	3.62	4.51	4.08	3.93	1.87	1.25	0.43	0.21
1859	0.26	1.24	1.70	2.39	3.05	4.35	5.63	3.63	2.69	1.48	1.52	1.10
1860	1.01	1.10	1.52	2.68	2.80	3.96	3.21	2.50	1.90	0.97	0.49	0.71
Mean	0.66	1.12	1.51	2.66	3.16	4.27	4.31	3.35	2.15	1.23	0.81	0.67
Mean Daily	.021	.040	.049	.089	.105	.142	.140	.108	.072	.040	.027	.022

Mean of Minimum Temperature of each 24 Hours.

	deg.	deg.	deg.	deg.	deg.	deg.	deg.	deg.	deg.	deg.	deg.	deg.
1858	32.7	31.1	33.0	38.8	42.5	50.6	49.8	50.5	51.2	42.6	34.5	36.9
1859	35.8	36.1	39.0	38.5	43.9	48.8	55.4	53.1	48.6	44.4	37.6	31.9
1860	34.6	29.9	35.5	34.8	45.3	47.4	49.0	49.4	44.0	42.9	36.1	31.6

Mean of Maximum Temperature of each 24 Hours.

1858	45.1	43.4	50.9	57.2	59.8	72.9	68.5	70.2	67.0	57.9	47.2	46.3
1859	46.2	49.3	51.8	55.0	64.3	70.0	78.1	72.3	64.3	59.6	51.5	43.3
1860	46.2	43.5	48.1	52.2	62.1	60.2	66.9	63.2	63.3	57.8	47.9	43.7

Comparison of Rainfall, Evaporation, and Temperature.

Year.	Rainfall.		Evaporation.		Temperature.		
	Annual.	Mean Daily.	Annual.	Mean Daily.	Annual.	Daily Max.	Daily Min.
	in.	in.	in.	in.	Deg. Fah.	Deg. Fah	Deg. Fah.
1858	36.41	.100	25.86	.071	48.4	57.2	41.2
1859	38.98	.107	29.04	.080	50.1	58.8	42.8
1860	48.93	.133	22.85	.062	46.7	54.6	40.0

BRITISH RAINFALL AND EVAPORATION.

RADCLIFFE OBSERVATORY, OXFORD.

Latitude 51° 45′ North; Longitude 1° 15′ West; Height above Sea 210 feet.
The evaporation is calculated from observations of the dry and wet bulb thermometers.

Rainfall.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
1852	5.3	1.0	0.6	0.6	2.1	7.1	2.8	4.5	3.1	2.7	7.1	3.5
1853	2.5	1.2	1.0	2.4	2.3	3.2	3.4	2.8	2.0	4.0	1.0	0.4
1854	2.1	0.9	0.4	0.8	3.2	1.8	1.5	1.8	0.4	2.3	1.3	1.2
1855	0.3	1.3	2.2	0.4	1.8	2.4	5.1	1.7	2.3	5.6	1.0	1.1
1856	2.9	1.3	0.9	2.6	4.3	2.5	0.6	3.2	3.2	2.4	1.0	2.0
Mean	2.6	1.1	1.0	1.4	2.7	3.4	2.7	2.8	2.2	3.4	2.3	1.6
Mean Daily	.084	.039	.032	.047	.087	.113	.087	.090	.073	.110	.077	.052

Greatest Fall of Rain in 24 Hours.

1852	1.40	0.26	0.51	0.50	0.64	1.69	1.15	0.83	0.69	0.75	1.39	0.66
1853	0.37	0.48	0.22	0.40	0.88	0.71	1.82	0.82	0.37	0.55	0.70	0.18
1854	1.01	0.36	0.16	0.48	0.72	0.59	0.73	0.20	0.17	0.46	0.44	0.39
1855	0.18	0.61	0.52	0.26	0.49	0.80	1.65	0.46	0.77	0.83	0.53	0.43
1856	0.46	0.30	0.53	0.61	1.32	1.27	0.17	0.87	0.68	0.57	0.45	0.26

Number of Days on which Rain Fell.

1852	22	14	4	3	13	24	7	20	13	15	22	21
1853	19	7	12	17	11	18	22	15	12	25	12	9
1854	16	10	9	6	20	13	15	10	10	17	14	18
1855	6	6	13	7	13	14	15	12	7	20	14	14
1856	20	7	5	14	18	8	8	14	12	19	13	16

Mean Monthly Evaporation.

1852	1.33	1.77	2.45	3.90	3.93	3.51	5.85	4.12	2.64	2.31	1.53	1.40
1853	1.36	2.62	1.49	3.63	4.00	3.78	4.31	4.06	3.09	1.98	0.78	0.74
1854	0.68	1.71	2.36	4.77	3.22	3.57	5.08	4.53	4.62	2.51	1.35	1.80
1855	0.62	0.48	1.27	3.36	3.63	2.76	2.76	4.74	3.66	2.08	1.26	1.18
1856	0.16	0.64	0.53	1.95	2.80	3.33	5.45	4.50	2.04	0.99	1.17	0.99
Mean	0.83	1.44	1.62	3.52	3.51	3.39	4.69	4.39	3.21	1.97	1.22	1.22
Mean Daily	.037	.052	.052	.117	.113	.113	.151	.142	.107	.064	.041	.039

Mean of Minimum Temperature of each 24 Hours.

	deg.	deg.	deg.	deg.	deg.	deg.	deg.	deg.	deg.	deg.	deg.	deg.
1852	35.0	35.2	32.2	35.1	43.4	50.0	56.7	54.4	48.5	40.1	43.0	42.5
1853	36.8	28.9	31.0	39.9	43.0	51.1	54.0	51.5	47.0	45.3	36.1	29.6
1854	34.7	33.3	36.0	38.4	42.3	49.5	52.8	51.3	47.1	42.1	35.6	35.9
1855	32.3	23.2	31.8	37.2	41.0	49.1	55.9	54.0	50.9	45.9	38.1	31.9
1856	35.7	37.6	32.9	39.4	42.2	49.9	52.4	54.5	47.3	44.5	36.1	34.5

Mean of Maximum Temperature of each 24 Hours.

1852	47.6	46.0	49.2	56.7	60.3	65.4	76.8	69.6	64.5	54.3	53.3	52.1
1853	46.9	37.7	45.8	54.7	62.2	68.3	70.1	68.5	63.2	57.1	47.7	38.7
1854	44.1	46.4	52.2	59.1	61.2	65.5	70.7	69.7	68.4	57.1	46.8	46.9
1855	39.9	35.1	45.8	55.5	59.1	66.9	73.0	71.1	66.1	57.2	46.0	42.2
1856	44.3	46.7	46.3	55.3	57.1	68.3	71.9	72.9	62.2	57.0	46.6	45.1

Comparison of Rainfall, Evaporation, and Temperature.

Year.	Rainfall.		Evaporation.		Temperature.		
	Annual.	Mean Daily.	Annual.	Mean Daily.	Annual.	Daily Max.	Daily Min.
	in.	in.	in.	in.	Deg. Fah.	Deg. Fah.	Deg. Fah.
1852	40.4	0.111	34.79	0.095	50.0	58.0	43.0
1853	26.2	0.072	31.84	0.078	47.5	55.1	41.2
1854	17.7	0.048	36.20	0.100	49.2	57.3	41.6
1855	25.2	0.069	27.80	0.076	47.2	54.8	41.0
1856	26.9	0.073	24.55	0.067	48.7	56.1	42.3

TROPICAL RAINFALL AND EVAPORATION.

GEORGETOWN OBSERVATORY, DEMERARA.

Latitude 6° 50′ North; Longitude 59° 23′ West; Height above Sea 10 feet.

Rainfall.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
1852	6.07	8.41	8.76	5.28	16.50	11.67	8.83	10.11	1.17	0.52	5.02	12.18
1853	6.78	5.42	1.25	5.51	15.72	13.22	9.82	4.95	4.11	1.23	2.39	4.45
1854	15.88	5.53	4.68	6.58	9.24	10.05	12.14	9.76	3.84	0.30	3.59	13.57
1855	2.18	15.39	12.82	6.82	10.86	12.76	14.00	6.28	1.12	4.26	0.93	5.89
1856	2.02	0.96	1.65	3.05	10.23	16.70	13.23	7.80	5.84	3.14	5.78	17.34
Mean.	6.58	7.14	5.83	5.44	12.51	12.88	11.60	7.78	3.21	1.89	3.54	10.68
Mean daily	0.213	0.287	0.188	0.182	0.417	0.430	0.374	0.251	0.107	0.060	0.118	0.344

Greatest Fall of Rain in 24 Hours.

1854	3.02	1.13	1.52	3.04	2.37	2.12	4.01	3.31	1.73	0.03	1.17	3.83
1855	0.88	5.44	2.58	1.74	2.85	1.77	4.81	1.97	0.62	2.90	0.52	1.28
1856	0.85	0.23	0.81	1.31	1.52	2.46	2.17	2.10	3.45	1.04	1.64	2.65

Greatest Evaporation in 24 Hours.

1854	.155	.130	.165	.188	.113	.110	.115	.118	.110	.136	.137	.104
1855	.125	.152	.140	.139	.111	.100	.115	.210	.150	.143	.133	.125
1856	.193	.187	.195	.190	.148	.148	.100	.102	.128	.153	.140	.103

Monthly Evaporation.

1854	2.66	3.12	3.60	3.26	2.63	2.25	2.13	2.26	2.82	3.62	3.02	2.37
1855	2.94	2.68	2.74	2.85	2.29	2.27	2.43	2.56	3.31	3.32	3.11	3.21
1856	4.02	4.67	5.17	4.02	2.74	2.30	2.05	1.84	3.07	3.07	2.60	2.36
Mean.	3.20	3.49	3.83	3.37	2.33	2.27	2.20	2.22	3.06	3.33	2.90	2.64
Mean daily	.103	.112	.137	.112	.075	.076	.070	.071	.102	.107	.096	.076

Mean of Minimum Temperature of each 24 Hours.

	deg.	deg.	deg.	deg.	deg.	deg.	deg.	deg.	deg.	deg.	deg.	deg.
1854	73.5	73.1	75.0	74.8	74.5	73.9	73.4	73.8	74.9	74.3	74.3	73.9
1855	75.5	74.0	73.8	74.8	74.7	73.9	73.6	74.1	75.1	74.9	75.4	74.6
1856	74.6	74.3	74.8	75.7	74.4	73.6	72.8	73.4	74.5	74.2	73.5	73.6

Mean of Maximum Temperature of each 24 Hours.

1854	81.6	81.7	82.8	83.4	84.1	84.1	84.1	85.6	86.4	87.1	86.2	83.5
1855	84.5	83.2	83.0	84.4	85.6	84.1	85.3	86.5	87.2	86.0	86.1	84.4
1856	83.1	83.4	83.8	84.3	83.1	83.2	82.9	85.5	86.0	85.7	84.6	82.8

Comparison of Rainfall, Evaporation, and Temperature.

Year.	Rainfall.		Evaporation.		Mean Temperature.		
	Annual.	Mean Daily.	Annual.	Mean Daily.	Annual.	Daily Min.	Daily Max.
	in.	in.	in.	in.	Deg. Fah.	Deg. Fah.	Deg. Fah.
1852	94.52	0.303	...	...	...	...	...
1853	74.85	0.205	...	...	...	...	...
1854	95.16	0.261	33.74	.181	79.1	74.1	84.2
1855	87.36	0.254	33.71	.224	80.6	76.2	85.0
1856	87.74	0.264	37.91	.194	79.1	74.1	84.0

TROPICAL RAINFALL AND EVAPORATION.

BOMBAY.

Latitude 18° 53′ North; Longitude 72° 51′ West; Height above Sea 35 feet.

Rainfall.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
1849	0.34	...	...	...	...	23.41	50.99	12.66	26.13	0.75	0.61	...
1850	...	...	...	...	...	14.80	20.15	5.38	4.77	4.89	0.25	...
1851	...	...	...	...	0.52	24.50	47.02	20.03	3.89	0.04	0.07	...
1852	...	...	0.01	...	0.30	21.76	22.17	11.16	12.67	0.19	...	1.01
1853	...	...	0.01	...	...	33.70	13.06	5.95	9.83	...	...	...
Mean	0.07	...	...	...	0.16	23.63	30.68	11.04	11.46	1.17	0.19	0.20
Mean Daily	.002	...	...	...	.005	.788	.990	.356	.382	.038	.006	.007

Greatest Fall of Rain in 24 Hours.

1849	0.30	...	...	...	...	5.01	6.35	2.25	4.55	0.29	0.60	...
1850	...	...	...	...	...	4.08	4.61	1.39	1.22	1.58	0.25	...
1851	...	...	...	...	0.30	5.53	4.72	6.42	2.21	1.02	0.07	...
1852	...	...	0.01	...	0.25	7.09	4.78	1.49	3.26	0.17	...	0.83
1853	...	...	0.01	...	9.89	1.48	1.51	3.60	3.60	...	...	...

Greatest Evaporation in 24 Hours.

1849	0.32	0.37	0.46	0.34	0.37	0.29	0.19	0.24	0.20	0.32	0.42	0.37
1850	0.33	0.38	0.38	0.43	0.34	0.35	0.23	0.22	0.22	0.51	0.43	0.34
1851	0.30	0.39	0.56	0.36	0.41	0.32	0.20	0.20	0.28	0.31	0.39	0.81
1852	0.38	0.40	0.49	0.39	0.46	0.41	0.17	0.24	0.24	0.33	0.35	0.38
1853	0.35	0.40	0.44	0.39	0.42	0.40	0.17	0.23	0.25	0.37	0.38	0.37

Monthly Evaporation.

1849	6.98	6.07	7.75	7.99	9.84	2.30	2.81	3.52	2.73	5.62	7.20	9.18
1850	6.77	7.39	7.98	8.48	8.17	5.70	3.80	4.37	4.97	6.49	8.64	7.11
1851	7.10	6.48	8.28	8.16	9.40	4.79	3.08	3.41	5.62	5.95	7.61	8.25
1852	8.33	7.25	9.30	9.20	11.71	6.51	3.70	4.37	4.20	6.59	7.17	7.74
1853	7.89	7.77	10.63	9.04	10.89	6.31	3.40	5.26	5.13	9.02	9.40	9.59
Mean.	7.41	6.99	8.79	8.57	10.00	5.12	3.36	4.18	4.53	6.73	8.00	8.37
Mean Daily	.240	.250	.283	.285	.322	.174	.108	.135	.151	.217	.266	.270

Mean of Minimum Temperature of each 24 Hours.

	deg.	deg.	deg.	deg.	deg.	deg.	deg.	deg.	deg.	deg.	deg.	deg.
1851	65.7	69.2	73.9	77.9	80.4	80.3	78.5	77.8	77.0	76.8	74.3	68.7
1852	65.4	69.4	73.9	77.1	81.2	80.7	79.8	78.0	77.8	77.2	74.7	70.8
1853	65.2	70.2	74.7	78.0	81.7	81.0	79.0	77.9	77.7	76.6	74.5	70.6

Mean of Maximum Temperature of each 24 Hours.

1851	79.4	82.7	86.6	89.5	90.2	86.0	82.0	83.3	84.9	87.4	86.2	83.8
1852	80.3	83.2	86.9	90.0	92.8	87.7	85.4	83.7	84.9	87.6	88.2	82.8
1853	79.9	84.2	88.4	90.1	93.2	87.1	83.1	84.8	85.0	89.1	87.9	86.0

Comparison of Rainfall, Evaporation, and Temperature.

Year.	Rainfall.		Evaporation.		Mean Temperature.		
	Annual.	Mean Daily.	Annual.	Mean Daily.	Annual.	Daily Max.	Daily Min.
	in.	in.	in.	in.	Deg. Fah.	Deg. Fah.	Deg. Fah.
1849	114.89	0.315	71.99	.197	80.1	84.9	75.3
1850	50.24	0.138	79.87	.219	80.4	85.6	75.2
1851	96.07	0.263	78.13	.214	80.1	85.2	75.0
1852	69.27	0.190	86.07	.236	81.3	86.1	75.5
1853	62.55	0.171	95.33	.258	81.1	86.6	75.6

RAINFALL AT EXETER.—Latitude 50° 42′ N. ; Longitude 4° 5′ W. ; Height above Sea 50 feet.

YEARS.	1815.	1816.	1817.	1818.	1819.	1820.	1821.	1822.	1823.	1824.	1825.	1826.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1838.	1839.	Mean of 25 Years
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Jan.	2.30	3.34	4.42	3.60	5.40	3.68	2.83	1.28	5.80	0.90	2.50	2.30	1.97	5.41	2.02	2.14	3.11	1.31	2.01	7.08	1.73	3.47	2.18	1.66	2.18	2.98
Feb.	2.30	1.95	1.23	3.94	4.27	1.38	0.32	2.51	4.61	2.06	2.15	4.23	1.14	3.30	1.64	0.92	3.12	0.84	7.81	1.70	3.23	1.65	4.07	5.39	1.71	2.70
March ...	3.92	2.81	1.98	5.78	0.27	0.62	4.49	1.52	2.17	2.83	2.98	2.67	4.07	1.25	2.48	0.83	2.33	2.62	1.76	0.81	3.24	4.90	1.36	2.64	2.72	2.52
April.....	0.70	1.00	0.00	6.33	2.42	1.44	3.43	2.89	1.38	3.44	2.15	0.88	1.68	3.81	5.92	2.93	2.95	1.20	3.44	0.97	1.17	2.74	1.61	1.61	1.78	2.32
May	3.60	1.33	3.67	1.56	3.55	2.23	3.06	0.57	2.28	2.65	2.53	1.99	2.92	3.27	0.70	2.56	1.49	1.81	0.62	1.23	2.55	1.17	1.20	2.89	1.25	2.11
June.....	2.60	1.67	2.66	0.76	2.25	0.57	1.96	0.87	1.71	2.63	1.18	0.35	1.11	3.63	4.52	3.61	0.95	2.32	5.11	2.95	1.78	1.98	1.47	4.01	5.36	2.32
July	0.95	5.36	2.22	0.80	2.40	1.05	2.68	3.71	2.82	1.40	0.00	1.08	1.47	4.50	5.61	2.26	2.17	1.54	0.77	3.30	0.59	2.08	2.15	1.35	4.51	2.27
August ..	0.70	2.30	4.59	0.07	2.20	2.17	2.33	1.53	2.16	1.57	1.29	2.50	2.29	2.59	2.65	3.07	1.80	5.10	0.60	2.13	2.08	0.74	4.19	1.85	2.02	2.18
Sept.....	1.85	1.28	0.44	6.78	2.64	2.42	3.10	1.33	1.10	2.30	2.79	5.29	4.15	3.42	5.43	3.29	2.17	0.38	1.98	1.96	4.02	3.49	2.87	1.57	4.16	2.81
October .	5.24	1.82	1.12	2.40	2.31	5.68	3.36	6.31	7.17	5.65	4.03	3.40	6.02	2.21	1.21	0.50	5.52	4.00	3.34	1.25	5.78	4.24	1.70	3.58	4.81	3.71
Nov.	1.90	3.39	2.79	4.16	2.74	1.62	5.44	5.87	1.91	5.28	2.85	2.36	2.37	3.09	1.03	5.55	3.49	5.72	3.15	2.23	4.48	6.55	2.50	10.26	5.44	3.85
Dec.	2.20	7.34	4.13	3.12	4.35	2.49	8.58	1.10	4.68	4.66	4.27	3.48	4.04	3.93	0.71	5.05	5.78	3.37	4.66	1.04	0.93	3.17	2.33	2.18	5.12	3.71
Totals ...	28.26	33.59	29.25	39.30	34.80	25.35	41.58	29.49	37.79	35.46	28.72	30.53	33.23	40.41	34.05	32.71	34.88	30.21	35.25	26.65	31.58	36.18	27.63	38.99	41.05	33.48
Mean of 5 years		33.04				33.93					33.40					31.94					35.09					
WINTER.		9.39	16.38	14.46	16.95	12.15	7.26	17.81	17.38	9.55	14.59	13.65	8.95	15.12	10.68	4.80	16.83	11.42	18.91	16.59	8.23	10.53	15.97	11.88	16.33	13.24
Mean of 5 years		14.29				12.83					12.60					13.71					12.59					
SPRING.	10.82	6.81	8.31	14.43	8.49	4.86	12.94	5.85	7.54	11.55	8.84	5.89	9.78	11.96	13.75	9.93	7.72	7.95	10.93	5.96	8.74	10.79	5.64	11.15	11.14	9.27
Mean of 5 years		9.77				8.55					10.04					8.50					9.49					
SUMMER.	8.74	10.76	8.37	10.05	9.55	11.32	11.47	12.88	13.25	11.01	8.11	12.27	13.93	12.72	14.94	9.12	11.66	11.02	6.69	8.64	12.47	10.55	10.91	8.35	15.50	10.97
Mean of 5 years		9.49				11.98					12.39					9.42					11.55					

Height of Gauge above ground 3 feet.

RAINFALL AT EXETER.—(*Continued.*)

YEARS.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	Mean of 20 Years.	Mean of 45 Years.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January ...	4.97	3.93	4.29	4.50	2.77	3.62	3.59	3.14	2.82	2.21	2.40	5.84	6.67	2.84	3.03	0.00	4.95	2.30	0.45	2.15	3.32	3.13
February ..	3.85	2.76	2.29	3.80	2.92	2.03	1.79	1.90	4.47	1.49	1.55	0.63	0.80	2.95	0.66	2.40	2.59	2.46	2.83	2.48	2.33	2.54
March	0.06	3.25	3.18	1.55	3.15	0.45	2.55	3.54	3.35	0.99	0.74	5.00	1.18	1.54	0.34	2.42	2.42	4.48	1.00	1.66	2.14	2.35
April	0.40	2.24	0.54	4.46	0.37	1.04	4.31	2.51	4.92	2.58	4.11	2.20	1.36	2.46	0.22	0.53	3.43	3.97	5.20	3.42	2.51	2.40
May	1.60	2.80	1.44	4.77	0.10	1.64	3.27	2.17	1.17	2.60	2.29	1.43	2.49	2.41	2.24	2.74	3.13	3.29	0.63	1.32	2.18	2.14
June.....	0.78	2.38	1.27	3.01	1.53	2.29	1.16	1.53	3.29	0.81	2.60	1.09	4.25	2.74	2.49	3.37	0.99	2.06	1.52	2.39	2.08	2.21
July	1.58	2.07	1.45	1.37	1.37	1.73	5.10	1.42	1.68	2.62	2.00	2.07	0.52	2.19	3.62	4.14	1.60	1.33	3.17	1.39	2.12	2.21
August.....	1.29	2.52	3.78	2.90	3.08	2.38	2.24	0.97	3.74	0.87	2.31	1.87	6.29	2.23	1.34	1.35	2.40	0.45	0.70	2.03	2.24	2.21
September	1.93	6.21	2.23	1.28	1.54	4.23	1.94	0.48	4.56	3.42	4.74	0.80	3.24	1.83	0.45	1.03	3.66	1.76	2.92	3.72	2.60	2.72
October ...	2.16	4.08	1.58	5.94	3.33	2.10	5.33	7.50	3.18	2.54	1.98	2.66	4.91	4.39	3.33	3.59	2.69	6.17	2.49	5.58	3.78	3.74
November.	6.61	6.46	7.63	3.92	3.83	4.63	3.51	2.93	1.55	2.54	3.23	2.28	8.53	2.70	1.74	0.89	0.30	1.46	4.14	4.75	3.68	3.77
December .	0.78	4.20	1.71	0.82	3.63	3.02	1.15	5.50	6.04	4.09	2.87	2.38	6.93	2.21	2.84	2.80	5.13	0.93	3.97	3.39	3.22	3.49
Totals	26.01	42.90	31.39	38.32	27.62	29.16	35.94	33.59	40.77	26.76	30.82	28.25	47.17	30.49	22.30	25.26	33.29	30.66	29.02	34.28	32.20	32.91
Mean of 5 years...		33.25				33.24					31.81					30.50						
WINTER.	19.38	14.08	17.24	17.64	10.43	13.11	13.03	9.70	15.72	11.29	10.58	12.57	12.13	21.25	8.60	6.98	11.23	10.19	5.67	12.74	12.68	12.94
Mean of 5 years...		15.27				12.57					13.03					9.36						
SPRING.	2.84	10.67	6.43	13.79	5.15	5.42	11.29	9.75	12.73	6.98	9.74	9.72	9.28	9.15	5.29	9.06	9.97	13.80	8.35	8.79	8.91	9.11
Mean of 5 years...		7.78				9.23					8.64					9.99						
SUMMER.	6.96	14.88	9.04	11.49	9.32	10.44	14.61	10.37	13.16	9.45	11.03	7.40	14.96	10.64	8.74	10.11	10.35	9.71	9.28	12.72	10.73	10.86
Mean of 5 years...		10.34				11.61					10.55					10.43						

Gauge kept at St. Thomas's Hospital.

RAINFALL AT SANDHURST.—40 YEARS' OBSERVATIONS.

Latitude 51° 24′ N.; Longitude 0° 45′ W.; Height above Sea 300 feet.

YEARS.	1820.	1821.	1822.	1823.	1824.	1825.	1826.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1838.	1839.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	1.4	1.7	0.3	1.7	1.2	1.0	1.7	0.9	4.4	0.0	1.7	1.9	1.2	0.5	3.1	0.5	1.8	2.1	0.1	0.7
February	0.5	0.1	1.2	1.7	3.5	1.8	1.9	0.0	0.7	1.9	1.8	2.2	0.1	4.6	0.3	2.6	2.0	2.3	1.6	1.0
March	0.1	3.1	1.0	1.5	1.5	0.2	0.2	3.0	0.8	1.5	1.5	2.2	2.1	1.3	0.5	1.8	3.1	0.3	0.6	1.3
April	1.6	2.4	2.6	1.6	1.4	2.4	1.1	1.1	2.3	1.6	1.6	1.0	1.1	2.1	0.4	0.9	3.4	1.0	0.4	0.7
May	2.5	1.7	1.5	1.9	6.1	2.0	0.0	1.5	2.1	0.7	1.9	1.9	1.4	0.6	1.1	3.1	0.4	0.6	0.1	0.7
June	2.0	1.3	0.7	1.6	3.3	1.5	2.0	1.1	1.9	2.3	1.6	1.5	2.3	2.2	1.7	1.8	1.9	1.1	1.9	1.6
July	2.2	4.8	2.6	2.2	1.4	0.0	1.5	0.8	5.5	4.0	2.2	2.9	0.9	1.9	6.2	0.4	1.6	1.4	1.2	3.6
August	3.0	2.4	0.2	2.6	1.8	2.2	1.5	2.0	4.0	3.0	2.6	1.3	3.5	1.2	2.0	0.0	1.5	1.9	0.7	1.8
September	2.7	4.3	1.1	2.3	3.7	3.5	5.0	4.5	3.2	3.6	2.3	4.3	0.4	1.4	1.1	2.8	3.0	1.1	2.0	3.8
October	2.6	3.3	4.7	3.4	3.0	3.4	3.4	3.5	3.4	1.7	0.8	4.3	3.4	2.2	0.5	5.4	3.8	1.9	2.2	1.9
November	1.5	5.4	3.9	2.6	3.3	2.9	4.7	1.7	1.1	1.2	3.6	1.5	2.9	2.8	1.8	2.0	3.0	1.3	3.5	3.5
December	2.0	6.4	1.7	1.4	3.4	4.3	0.9	3.2	2.1	1.4	1.5	3.1	1.4	4.2	0.5	0.0	1.3	1.5	1.5	3.1
Total	22.1	36.9	21.5	24.5	33.6	25.2	23.9	23.3	31.5	22.9	23.1	28.1	20.7	25.0	19.2	21.3	26.8	16.5	15.8	23.7
Mean of 5 Years	27.7					25.4					23.2					20.8				
WINTER.	5.4	5.3	13.3	9.0	8.7	9.5	10.8	6.5	10.0	5.1	6.1	9.2	5.9	9.4	10.4	5.4	5.8	8.7	4.5	6.7
Mean of 5 Years	8.3					8.4					8.2					6.2				
SPRING.	6.2	8.5	5.8	6.6	12.3	6.1	3.3	6.7	7.1	6.1	6.6	6.6	6.9	6.2	3.7	7.6	8.8	3.0	3.0	4.3
Mean of 5 Years	7.9					5.9					6.0					5.3				
SUMMER.	10.5	14.8	8.6	10.5	9.9	9.1	11.4	10.8	16.1	12.3	7.9	12.8	8.2	6.7	9.8	8.6	9.9	6.3	6.1	11.1
Mean of 5 Years	10.9					11.9					9.1					8.4				

RAINFALL AT SANDHURST.—(*Continued.*)

YEARS.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	Mean of 40 Years.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	2.5	2.5	1.1	1.5	2.4	2.4	2.9	0.9	1.5	1.4	0.8	3.0	3.4	3.0	1.1	0.0	2.7	2.3	0.6	0.7	1.6
February	0.2	0.9	1.6	1.8	2.4	0.8	1.0	1.0	2.2	1.5	1.3	0.9	1.2	4.0	0.8	1.6	0.8	0.4	1.2	1.9	1.5
March	0.2	1.7	1.9	1.1	2.2	1.1	0.9	0.6	2.5	0.9	0.2	3.8	0.4	1.5	0.4	2.0	0.9	1.3	0.6	1.4	1.3
April	0.1	1.8	0.1	1.9	0.2	0.9	2.7	1.1	2.7	3.1	2.7	1.5	0.8	3.2	0.3	0.5	3.3	1.8	2.4	2.4	1.6
May	1.8	3.2	1.1	4.7	0.2	2.2	1.9	1.1	0.0	2.8	2.2	1.1	1.5	2.1	4.4	2.4	3.0	0.9	1.8	1.8	1.8
June	0.7	1.8	1.5	1.6	1.7	1.1	0.8	1.1	3.6	0.4	1.2	0.9	4.9	2.0	1.8	0.9	1.0	2.7	0.7	1.7	1.7
July	1.7	1.4	0.9	1.4	1.3	2.3	1.1	0.6	2.2	3.7	3.4	3.2	3.6	3.6	1.8	5.7	1.0	1.7	2.8	1.2	2.3
August	1.8	2.4	3.5	3.6	1.9	2.5	3.4	1.1	4.3	0.7	1.6	2.2	2.8	2.5	0.9	2.2	2.5	2.8	1.6	3.0	2.2
September	2.1	5.7	2.6	0.4	1.2	1.6	1.8	1.3	2.4	2.4	1.1	0.2	4.4	1.5	0.6	2.3	2.6	3.6	1.3	3.3	2.5
October	1.3	4.7	1.2	4.2	4.2	2.4	5.3	2.6	3.5	2.5	1.3	2.4	4.5	4.2	2.6	5.5	2.2	5.6	1.5	3.3	3.1
November	4.4	3.5	4.8	2.1	2.8	3.2	1.8	1.6	1.2	1.0	2.0	0.6	6.0	1.1	1.4	1.1	1.0	2.0	0.7	3.1	2.5
December	0.4	2.0	0.9	0.8	0.2	2.4	1.1	2.6	2.6	1.9	1.3	0.9	2.1	0.0	1.2	1.3	3.2	0.5	2.1	2.2	1.9
Total	17.2	31.6	21.2	25.1	20.7	22.9	24.7	15.6	28.4	22.3	19.1	20.7	35.6	28.7	17.3	25.5	24.2	25.6	17.3	26.0	24.0
Mean of 5 years.	23.2					22.8					24.3					23.7					
WINTER.	9.3	8.2	8.2	9.0	7.7	6.2	9.5	4.8	7.7	6.7	5.0	7.2	6.1	15.1	3.0	4.2	5.9	6.9	4.3	5.4	7.5
Mean of 5 Years.	8.5					7.0					7.3					5.3					
SPRING.	2.8	8.5	4.6	9.3	4.3	5.3	6.3	3.9	8.7	7.2	6.3	7.3	7.6	8.8	6.9	5.8	8.2	6.7	5.5	7.3	6.4
Mean of 5 Years.	5.9					6.3					7.4					6.7					
SUMMER.	6.9	14.2	8.2	9.6	8.6	8.8	11.6	5.6	12.4	9.3	7.4	8.0	15.3	11.8	5.9	15.1	8.3	13.7	7.2	10.8	10.1
Mean of 5 Years.	9.5					9.5					9.7					11.0					

RAINFALL AT COBHAM, SURREY.—35 YEARS' OBSERVATIONS.

Latitude 51° 17′ N.; Longitude 26′ 00′ W.; Height above Sea 80 feet.

YEARS.	1825.	1826.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1838.	1839.	1840.	1841.	1842.	1843.	1844.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	1.12	0.43	0.90	4.69	0.75	2.12	1.21	1.25	0.59	4.08	0.89	1.93	2.34	0.26	1.32	2.57	2.50	0.83	1.68	3.25
February	0.63	2.09	0.38	1.24	1.09	0.95	2.53	0.29	4.09	0.37	2.54	2.00	2.47	1.65	1.37	2.08	1.07	1.37	2.05	2.22
March	1.26	1.94	2.72	1.01	0.40	0.24	2.50	1.49	1.43	0.73	2.50	3.58	0.74	1.16	1.28	0.32	1.30	1.79	0.83	2.41
April	1.56	0.45	1.12	2.47	5.63	2.57	2.25	1.60	2.52	0.53	0.98	3.10	0.85	0.73	0.93	0.21	2.58	0.32	1.82	0.31
May	2.03	2.42	1.76	2.13	0.85	3.03	2.97	1.71	0.60	1.35	2.31	0.92	0.94	0.74	1.13	1.58	2.39	1.78	5.99	0.44
June	1.16	0.48	0.75	1.96	2.58	3.18	1.27	2.25	2.44	1.90	2.58	1.58	1.17	2.65	2.10	0.93	1.74	0.56	1.68	1.43
July	0.23	2.44	1.07	5.07	4.63	1.86	2.71	0.60	1.35	5.47	0.30	2.04	1.53	1.56	3.48	1.97	1.93	1.62	2.13	1.02
August	2.87	1.34	1.97	2.34	4.14	3.35	1.37	2.59	0.83	3.50	1.16	1.56	2.86	1.09	1.36	2.04	2.61	3.00	3.20	2.18
September	2.21	5.17	3.62	2.56	3.48	3.14	3.85	0.63	2.91	0.98	4.57	2.61	1.00	2.60	5.74	2.88	4.13	3.58	0.71	1.18
October	3.16	1.69	4.16	1.42	1.48	0.75	4.68	3.41	1.78	0.24	4.77	4.44	1.65	1.84	1.84	1.38	5.51	1.25	3.75	4.26
November	3.77	3.33	1.31	1.01	1.61	3.10	1.44	1.62	2.67	1.77	1.83	2.81	1.60	3.77	3.94	3.84	3.69	4.65	3.29	2.76
December	2.85	1.81	3.46	2.22	0.42	1.50	3.48	1.69	3.53	0.79	0.28	2.12	1.38	1.64	2.86	0.55	2.38	0.62	0.30	0.29
Total	22.85	23.59	23.22	28.12	27.06	25.79	30.26	19.13	24.74	21.71	24.71	28.69	18.53	19.69	27.35	20.35	31.83	21.37	27.43	21.75
Mean of 5 Years	24.97					24.32					23.79					24.55				
WINTER.		9.14	6.42	10.70	5.07	5.10	8.34	6.46	7.99	10.65	5.99	6.04	9.74	4.89	8.10	11.45	7.96	8.27	9.00	9.06
Mean of 5 Years	7.83					7.71					6.95					9.15				
SPRING.	6.01	5.29	6.35	7.57	9.46	9.02	8.99	7.05	6.99	4.51	8.37	9.18	3.70	5.28	5.44	3.04	8.01	4.45	10.32	4.59
Mean of 5 Years	6.93					7.31					6.39					6.08				
SUMMER.	8.47	10.64	10.82	11.39	13.73	9.10	12.61	7.23	6.87	10.19	10.80	10.65	7.04	7.09	12.42	8.27	14.18	9.45	9.79	8.64
Mean of 5 Years	11.01					9.20					9.60					10.06				

RAINFALL AT COBHAM.—(*Continued.*)

YEARS.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	Mean of 35 years
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	2.83	2.96	1.33	1.42	1.44	0.84	2.93	2.36	2.60	1.72	0.46	1.22	2.57	0.78	0.93	1.75
February	1.07	1.28	1.28	2.71	1.47	1.28	0.73	0.65	0.80	0.87	1.07	0.99	0.14	1.68	1.39	1.43
March	1.10	1.04	0.62	3.39	0.88	0.19	3.36	0.20	1.29	0.26	1.37	0.72	0.88	0.55	1.03	1.33
April	0.83	1.89	1.43	4.01	3.15	2.73	1.53	0.46	2.56	0.22	0.27	2.35	1.39	2.34	2.17	1.71
May	3.08	1.50	1.65	0.11	2.78	2.21	0.75	1.77	1.65	3.24	1.88	3.55	0.76	1.83	2.62	1.90
June	0.73	0.97	1.30	3.08	0.42	1.17	0.98	4.64	1.83	1.17	1.11	1.07	3.42	1.39	2.51	1.72
July	2.82	2.17	1.48	2.36	3.66	3.39	2.09	3.36	5.15	1.39	6.39	0.73	1.23	2.47	1.90	2.39
August	2.56	2.91	1.02	3.44	0.69	1.56	1.35	4.89	2.16	1.61	1.02	3.17	2.70	2.00	1.76	2.23
September	1.69	2.07	1.52	2.26	2.42	1.14	0.20	3.68	2.10	0.70	1.15	2.01	3.77	0.86	2.69	2.45
October	1.56	5.73	2.44	3.50	2.47	1.43	2.20	4.41	3.68	2.63	5.21	2.35	4.83	1.48	2.76	2.86
November	2.70	1.42	1.82	1.31	1.00	2.02	0.74	5.54	0.93	1.37	1.95	1.07	1.45	0.82	3.13	2.31
December	1.61	1.26	2.63	2.77	1.87	1.51	0.52	2.23	0.44	1.40	1.44	1.98	0.48	1.67	2.42	1.67
Total	22.58	25.20	18.52	30.36	22.25	19.47	17.38	34.19	25.19	16.58	23.32	21.21	23.62	17.87	25.31	23.75
Mean of 5 years			23.78					22.56					22.27			
WINTER.	6.95	8.55	5.29	8.58	6.99	4.99	7.19	4.27	11.17	3.96	4.30	5.60	5.76	4.39	4.81	7.17
Mean of 5 years			7.27					6.32					4.97			
SPRING.	5.74	5.40	5.00	10.59	7.23	6.30	6.62	7.07	7.33	4.89	4.63	7.69	6.45	6.11	8.33	6.65
Mean of 5 years			6.79					6.44					6.64			
SUMMER.	8.63	12.88	6.46	11.56	9.24	7.52	5.84	16.34	13.09	6.33	13.77	8.26	12.53	6.81	9.11	9.93
Mean of 5 years			9.75					9.82					10.10			

RAINFALL AT GREENWICH.—Latitude 51° 28′ 38″ N.; Longitude 0° 00′; Height above Sea 158 feet.

YEARS.	1820.	1821.	1822.	1823.	1824.	1825.	1826.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1838.	1839.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	1.9	2.4	.3	1.5	1.0	1.1	.3	1.2	4.3	.5	1.7	1.1	1.2	1.1	3.1	.7	1.9	2.6	.9	1.2
February	.7	.0	1.1	3.5	2.5	1.0	1.9	.7	1.1	1.3	2.5	3.1	.0	3.6	.4	2.6	1.8	1.7	2.0	1.5
March	.0	3.9	1.5	1.5	1.9	1.4	1.9	2.6	1.0	.7	.3	2.2	1.4	1.0	.7	2.5	2.2	.6	1.0	1.8
April	1.6	2.0	2.9	2.0	2.1	2.0	1.1	1.3	2.4	4.8	3.1	3.4	.5	1.2	.6	1.1	2.7	1.2	.5	1.4
May	3.9	2.4	2.1	.8	4.2	3.3	2.7	2.6	1.7	.6	2.2	1.6	1.5	.2	1.0	3.1	1.3	1.0	1 5	1.7
June	2.3	2.4	.9	1.2	3.8	.8	1.1	.7	2.1	1.6	2.6	2.1	3.3	2.1	1.5	2.4	1.1	1.1	5.1	1.9
July	4.8	3.1	4.5	3.6	2.0	.1	2.6	1.4	7.0	4.2	1.9	3.4	.7	1.7	5.3	.3	1.9	1.5	2.0	3.7
August	1.9	2.1	2.0	3.0	4.4	2.7	1.9	1.2	4.2	4.5	4.0	2.0	3.4	1.8	3.3	1.1	2.6	4.6	1.0	2.8
September	2.4	3.7	1.5	1.0	3.5	2.8	3.4	3.9	2.7	3.6	3.5	2.2	.4	1.9	.9	4.2	3.2	1.2	2.8	4.9
October	2.9	2.7	3.9	4.4	2.6	3.0	1.9	4.3	1.5	1.9	.8	5.5	2.5	1.3	0.4	4.2	4.2	2.5	2.0	1.9
November	2.0	4.7	4.1	1.8	4.3	3.2	2.8	1.3	1.0	1.4	3.4	4.1	1.7	2.3	1.3	2.2	2.4	1.7	3.2	4.4
December	1.8	5.2	2.5	2.8	4.0	3.2	1.4	3.6	2.5	0.1	1.2		1.1	4.8	1.1	.4	1.8	1.3	1.8	2.4
Totals	26.2	34.6	27.3	27.1	36.3	24.6	23.0	24.8	31.5	25.2	27.2	30.7	17.7	23.0	19.6	24.8	27.1	21.0	23.8	29.6
Mean of 5 Years	30.3					25.8					23.6					25.2				
WINTER.		6.2	11.3	11.6	8.1	10.4	8.6	6.1	10.3	5.3	5.7	8.8	5.3	7.5	10.6	5.7	6.3	8.5	5.9	7.7
Mean of 5 Years	9.3					8.1					7.6					7.0				
SPRING.	7.8	10.7	7.4	5.5	12.0	7.5	6.8	7.2	7.2	7.7	8.2	9.3	6.7	4.5	3.8	9.1	7.3	3.8	8.1	6.8
Mean of 5 Years	8.7					7.3					6.5					7.0				
SUMMER.	12.0	11.6	11.9	12.0	12.5	8.6	9.8	10.8	15.4	14.2	10.2	13.1	7.0	6.7	9.9	9.8	11.9	9.9	7.9	13.3
Mean of 5 Years	12.0					11.7					9.4					10.5				

RAINFALL AT GREENWICH.—(*Continued.*)

YEARS.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	Mean of 40 Years.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	2.4	2.1	1.0	1.4	2.4	2.4	2.8	1.4	1.2	1.6	1.2	2.7	3.6	2.0	1.7	1.0	2.3	2.6	0.7	0.8	1.7
February	1.2	1.3	1.1	2.4	2.3	.9	1.5	1.4	2.6	2.2	1.3	1.2	.9	.9	1.0	1.4	.9	0.2	1.7	0.9	1.5
March	.3	1.3	1.9	.5	2.9	1.5	.9	.8	3.1	.5	.3	4.1	.2	1.5	.4	1.5	1.2	0.8	0.9	1.3	1.4
April	.1	1.9	.4	1.7	.4	.6	3.1	1.0	3.4	2.2	2.3	2.3	.5	3.1	.6	0.1	2.3	1.4	2.4	2.2	1.7
May	2.1	2.1	2.1	3.8	.4	2.2	1.5	1.4	.4	3.9	2.4	.8	1.9	1.6	3.3	1.8	3.5	0.6	1.8	2.4	2.0
June	1.5	2.7	1.0	1.3	1.8	1.9	.5	1.5	3.5	.2	.9	1.3	4.6	2.8	1.0	.7	1.6	2.7	1.2	1.4	1.8
July	1.7	3.6	3.0	2.4	2.8	1.9	1.5	.7	2.0	2.9	2.9	2.8	2.3	6.0	1.7	5.0	0.9	1.1	2.9	3.3	2.7
August	1.1	2.2	1.8	3.6	2.0	3.1	4.0	2.0	4.3	.5	1.9	1.5	4.5	2.2	2.9	1.1	2.4	2.6	1.6	1.1	2.6
September	2.9	4.0	4.0	.5	1.2	2.1	1.8	1.6	2.4	3.3	1.3	.8	3.9	2.4	0.7	1.1	2.8	3.4	0.9	3.8	2.4
October	1.6	6.0	1.4	4.3	4.0	1.4	5.1	2.0	3.5	2.7	1.4	1.8	3.8	4.3	2.6	4.9	1.6	4.2	1.2	2.6	2.9
November	2.9	3.7	4.2	2.3	4.3	2.4	1.5	2.0	1.2	1.5	2.5	.6	6.0	1.5	1.4	1.3	1.0	1.3	0.4	2.8	2.4
December	.4	2.4	.7	.4	.4	2.0	1.1	2.0	2.6	2.4	1.3	.6	2.2	.7	1.4	1.2	1.3	0.5	1.5	2.3	1.8
Totals	18.2	33.3	22.6	24.6	24.9	22.4	25.3	17.8	30.2	23.9	19.7	20.5	34.4	29.0	18.7	21.1	21.8	21.4	17.2	24.9	24.9
Mean of 5 years.	24.7					23.9					24.4					21.2					
WINTER.	10.4	6.7	8.2	8.7	7.4	8.0	8.7	5.4	7.8	7.6	6.4	7.7	5.5	11.1	4.9	5.2	5.7	5.1	4.2	3.6	7.4
Mean of 5 Years.	8.3					7.5					7.1					4.7					
SPRING.	4.0	8.0	5.4	7.3	5.5	6.2	6.0	4.7	10.4	6.8	5.9	8.5	7.2	9.0	5.3	4.1	8.6	5.5	6.3	11.3	7.0
Mean of 5 Years.	6.0					6.8					7.2					7.1					
SUMMER.	7.3	15.8	10.2	10.8	10.0	8.5	12.4	6.3	12.2	9.4	7.5	6.9	14.5	14.9	7.9	12.1	7.7	11.3	6.6	10.8	10.5
Mean of 5 Years.	10.8					9.7					10.3					9.7					

RAIN-FALL AT CHISWICK.—Latitude 51° 29′ N.; Longitude 0° 17′ W.; Height above the Sea 24 feet.

YEARS.	1826.	1827.	1828.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1838.	1839.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	Means of 25 years.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Jan.	.27	.57	3.71	.30	1.54	1.02	1.32	.52	2.87	.72	2.01	3.03	.27	1.27	2.48	2.60	1.06	1.33	2.25	2.97	2.85	1.31	1.16	1.73	1.43	1.6
Feb.	1.71	.79	.94	1.07	1.33	2.27	.23	3.98	.37	2.61	1.61	2.01	2.22	2.19	1.25	.76	1.32	2.35	2.27	.93	1.47	1 34	3.12	2.52	.95	1.7
March ...	1.62	2.50	.59	.75	.18	1.91	1.50	1.22	.86	1.97	3.30	.54	.86	1.95	.28	1.32	1.81	.47	2.44	1.25	1.09	.41	3.05	.85	.13	1.3
April.....	.88	.71	2.44	4.49	2.84	1.96	.95	2.71	.65	1.07	2.88	1.13	.52	1.46	.06	1.58	.15	1.62	.33	.95	3.93	.92	3.06	2.21	1.79	1.7
May	2.59	2.24	1.40	.52	2.47	2.21	2.16	.68	1.19	3.38	1.01	1.07	.92	.82	2.18	2.16	1.73	5.26	.25	2.89	1.35	1.59	.28	3.53	1.84	1.8
June.....	.38	.82	1.94	2.37	2.62	1.37	2.89	2.63	1.63	1.99	1.66	1.31	3.05	3.00	1.48	2.45	1.58	1.62	.97	1.36	.80	1.31	3.20	.31	1.40	1.8
July	2.07	1.31	4.38	5.23	1.46	2.52	.89	1.56	6.34	.41	1.78	1.78	2.19	2.92	1.68	3.56	1.52	1.67	2.10	2.31	1.78	.79	2.21	2.82	2.68	2.3
August...	2.00	1.66	4.35	4.07	3.05	1.59	3.62	1.93	2.73	.18	1.97	3.04	1.23	1.85	1.62	2.69	2.81	3.28	1.84	2.79	4.50	1.50	4.70	1.60	.97	2.5
Sept.....	3.71	3.37	4.03	3.71	3.21	4.19	1.12	1.55	.83	4.60	3.81	.91	2.08	3.92	2.45	3.71	3.39	.98	1.31	1.77	1.76	1.66	2.20	2.49	2.36	2.6
October	2.14	4.06	1.18	1.60	.98	3.81	3.09	2.35	.43	4.05	3.62	2.39	2.36	2.23	1.35	4.61	1.71	4.19	4.13	1.39	5.54	1.75	2.93	2.18	1.55	2.6
Nov.....	2.89	1.06	1.12	1.86	3.05	1.70	1.94	2.38	1.75	1.94	3.60	1.32	3.55	4.37	3.59	3.41	4.47	2.13	3.06	2.11	1.43	2.26	.90	1.32	2.03	2.4
Dec.	1.77	3.09	1.77	.15	1.54	2.38	1.88	4.29	.74	.25	1.48	1.35	1.72	2.32	.45	2.12	.76	.58	.39	2.61	1.21	1.81	2.03	1.28	1.15	1.5
Totals ...	21.83	22.18	27.85	26.12	24.27	26.93	21.59	25.80	20.39	23.17	28.73	19.88	21.57	28.30	18.87	30.97	22.31	25.48	21.34	23.33	27.71	16.65	28.84	22.84	18.28	23.8
Mean of 5 years		24.45				23.57					23.47					24.68					22.86					
WINTER.		6.02	8.80	4.26	4.88	7.88	5.63	8.32	9.91	5.82	5.81	10.12	5.16	8.73	10.42	7.40	7.91	8.91	7.23	7.35	9.04	5.29	8.35	7.18	4.98	7.25
Mean of 5 years		5.99				7.51					8.05					7.76					6.97					
SPRING.	5.27	6.27	6.37	8.13	8.11	7.45	7.50	7.24	4.33	8.41	8.85	4.05	5 95	7.23	4.00	7.51	5.27	8.97	3.99	6.45	7.17	4.23	9.59	6.90	5.16	6.57
Mean of 5 years		6.83				6.98					6.01					6.44					6.61					
SUMMER.	9.92	10.40	13 94	14.61	8.70	12.11	8.72	7.39	10.33	9.24	11.18	8.12	7.86	10.92	7.10	14.57	9.63	10.12	9.38	8.26	13.58	5.70	12.04	9.09	7.56	10.02
Mean of 5 years		11.51				9.56					9.03					10.39					9.59					

Max. Fall: Mean 5 Wettest Years—Winter 9.68 Spring 8.79 Summer 13.75 Year 28.93.
Min. „ „ „ Dryest „ „ 4.91 „ 4.12 „ 7.12 „ 18.81.

RAINFALL AT EPPING, ESSEX.—30 YEARS' OBSERVATIONS.

Latitude 51° 40′ N.; Longitude 0° 6′ E.: Height above Sea 365 feet.

Years.	1822	1823	1824	1825	1826	1827	1828	1829	1830	1831	1832	1833	1834	1835	1836	1837	1838	1839	1840	1841	1842	1843	1844	1845	1846	1847	1848	1849	1850	1851	Mean of 30 years.
Days on which Rain fell.	112	156	175	145	156	178	174	182	171	189	172	170	154	171	211	178	171	216	174	218	181	192	180	191	175	181	208	169	166	178	
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	
January	.4	1.8	.9	1.0	.2	1.3	3.7	.7	1.8	1.8	1.0	.6	4.5	1.1	2.2	2.0	.4	1.4	2.9	2.4	1.5	1.2	2.4	2.7	3.9	1.8	1.2	2.2	1.6	3.4	1.8
February ...	1.4	3.3	2.5	.9	2.1	.7	1.3	1.2	1.7	2.6	.4	5.1	.7	2.9	1.6	2.4	2.0	2.0	1.3	1.2	1.6	1.9	3.3	.7	1.2	1.3	3.4	2.1	1.1	1.0	1.8
March	1.5	1.3	2.8	1.3	2.0	2.8	.7	.5	.5	2.2	1.5	1.0	.6	2.7	3.9	.2	1.2	1.9	.5	1.6	2.6	.7	2.2	2.1	1.2	.9	4.1	.8	.2	5.8	1.7
April	2.7	1.8	1.9	2.2	1.1	1.0	2.6	4.9	2.3	1.5	.7	2.5	.5	1.9	2.7	1.1	1.0	1.6	.0	1.5	.3	2.4	.4	1.2	2.7	1.3	2.7	2.1	3.1	1.9	1.8
May	1.2	1.0	3.8	2.5	2.4	3.0	1.4	.6	2.7	1.5	1.9	.9	1.0	1.5	1.0	1.2	.6	1.9	3.2	1.6	2.4	5.9	.4	1.3	1.1	2.4	.2	4.4	2.0	0.8	1.9
June	1.0	1.6	5.8	1.4	.4	1.0	2.0	2.7	3.6	2.5	3.2	2.8	1.7	2.1	2.1	1.1	3.6	2.2	1.3	3.0	2.3	1.8	2.1	2.5	.4	2.3	3.7	.5	.5	1.1	2.1
July	3.0	1.9	1.8	0.0	2.6	1.3	5.6	5.0	1.5	3.0	.9	2.3	4.3	.5	2.0	2.0	2.2	2.8	1.2	3.2	3.6	3.7	2.4	2.1	1.3	1.0	2.3	2.7	2.9	3.8	2.4
August	1.4	2.6	2.6	2.8	1.6	1.8	3.7	6.8	3.3	2.7	4.0	3.3	2.4	.9	1.3	3.2	1.3	2.3	1.3	3.2	2.1	2.7	2.4	2.2	3.7	1.4	3.1	1.0	1.1	2.3	2.5
September .	.8	2.2	4.1	3.4	3.5	3.4	3.3	4.2	3.7	5.2	.8	1.4	1.1	4.8	3.3	1.2	2.3	3.8	3.0	4.4	3.9	.4	1.9	1.8	2.7	2.3	2.4	3.1	1.5	.6	2.7
October	3.8	2.6	2.9	2.7	2.9	3.1	.8	2.1	.6	3.6	3.8	2.1	.4	5.5	4.3	2.1	2.4	1.6	2.0	0.7	2.0	6.2	4.7	1.6	5.4	2.1	3.9	2.2	1.7	2.3	2.9
November ..	3.8	2.1	3.9	3.9	3.0	1.9	1.3	1.2	3.2	1.6	2.0	2.3	1.8	2.3	3.7	1.9	3.0	5.0	3.4	4.4	5.2	2.2	3.9	2.4	1.3	1.8	1.3	1.8	2.4	1.0	2.6
December ...	1.6	3.1	3.3	3.5	1.7	4.5	2.3	.3	1.3	2.6	2.4	4.9	.9	.5	2.0	1.3	2.3	3.7	.5	3.0	1.1	.9	.4	2.9	1.0	2.6	2.4	2.7	1.5	.7	2.1
Total.....	22.6	25.3	36.3	26.6	23.5	25.8	28.7	30.2	26.2	31.0	22.6	29.2	19.9	26.7	30.1	19.7	22.3	30.2	20.6	36.2	28.6	30.0	26.4	23.6	25.9	21.2	30.7	25.6	19.6	24.7	26.3
Mean of 5 Years.	26.8					28.4					25.7					25.8					26.9					24.4					
WINTER.	...	10.6	8.6	9.1	9.6	6.7	11.3	5.5	5.1	8.8	5.6	10.1	12.4	6.6	6.6	10.2	5.6	8.8	12.9	7.5	10.6	9.3	8.9	7.8	10.4	5.4	9.0	8.0	7.3	8.4	8.4
Mean of 5 Years	9.5					7.5					8.2					9.0					9.4					7.6					
SPRING.	6.4	5.7	14.3	7.5	5.9	7.9	6.7	8.6	9.0	7.7	7 4	7.2	3.8	8.3	9.5	3.6	6.4	7.6	5.0	7.7	7.6	10.7	4.9	7.1	5.5	6.9	10.8	7.9	5.8	9.7	7.3
Mean of 5 Years.	7.9					8.0					7.2					6.1					7.2					8.2					
SUMMER.	8.9	9.3	11.4	9.4	10.6	9.5	13.4	18.1	9.2	14.6	9.5	9.2	8.2	11.8	10.9	8.6	8.2	10.5	7.6	17.5	11.7	13.0	11.5	7.7	13.1	6.8	11.8	9.0	7.2	9.0	10.6
Mean of 5 Years.	10.0					12.9					9.9					10.5					11.4					8.8					

Mean Annual Fall for 30 years — Winter 8.4 — Spring 7.3 — Summer 10.6 — Year 26.3

Max. Fall: Mean 5 Wettest Years— „ 11.6 „ 11.0 „ 15.3 Year 32.9

Min. „ „ „ Dryest „ „ 5.4 „ 4.6 „ 7.5 „ 20.3

RAINFALL AT FEILDE'S WEIR, HERTS.

Height above Sea 90 feet.

YEARS.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	Mean of 10 years.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	3.2	3.5	4.6	3.4	1.7	0.5	2.3	3.5	1.0	1.3	2.5
February	0.8	1.0	1.5	1.4	0.9	1.0	1.3	0.2	1.8	1.4	1.1
March	0.2	4.1	0.3	1.7	0.5	1.8	1.0	1.6	0.7	2.0	1.4
April	3.0	1.8	1.6	2.8	0.7	0.2	2.0	2.3	2.8	2.4	1.9
May	2.3	0.6	1.8	2.5	3.4	2.4	3.6	1.3	2.6	1.1	2.2
June	0.8	1.4	3.2	3.0	0.8	1.2	0.7	1.6	0.9	3.2	1.7
July	3.2	3.3	2.7	4.0	1.5	5.3	2.2	1.5	3.3	3.2	3.0
August	1.3	2.1	3.7	2.4	1.9	2.0	2.6	2.2	2.9	2.2	2.3
September	2.0	0.6	4.0	1.5	0.6	1.8	2.8	3.8	1.1	3.7	2.2
October	1.8	1.8	6.0	3.8	2.4	5.2	1.9	5.1	1.4	2.7	3.2
November	1.8	1.1	7.8	1.8	1.6	1.9	1.4	1.6	0.6	3.1	2.3
December	1.9	0.6	2.3	0.4	1.9	1.7	2.5	0.7	1.7	2.9	1.7
Total	22.3	21.9	39.5	28.7	17.9	25.0	24.3	25.4	20.8	29.2	25.5
Mean of 5 years			26.1					24.9			
WINTER.	7.8	8.2	7.8	14.9	4.8	5.0	7.2	7.6	5.1	5.0	7.4
Mean of 5 years			8.7					6.0			
SPRING.	6.3	7.9	6.9	10.0	5.4	5.6	7.3	6.8	7.0	8.7	7.2
Mean of 5 years			7.3					7.1			
SUMMER.	8.3	7.8	16.4	11.7	6.4	14.3	9.5	12.6	8.7	11.8	10.8
Mean of 5 years			10.1					11.4			

RAINFALL AT HITCHIN, HERTS.

Height above Sea 400 feet.

YEARS.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	Mean of 10 years.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	3.2	4.6	4.5	2.0	0.9	1.1	2.2	2.7	0.8	1.1	2.3
February	0.8	1.4	1.4	1.5	1.4	2.0	0.8	0.1	1.3	1.7	1.2
March	0.2	3.4	0.3	1.7	0.3	1.0	0.8	1.2	0.7	0.3	1.0
April	2.2	1.5	0.4	2.8	0.7	0.2	2.4	1.8	3.1	2.4	1.8
May	2.2	1.7	2.6	2.2	3.7	1.5	4.4	0.9	2.3	1.9	2.3
June	0.8	1.5	4.0	2.5	0.7	2.6	1.4	2.2	0.7	3.0	1.9
July	4.4	3.0	3.2	3.7	1.6	4.7	1.6	2.6	4.3	3.4	3.2
August	1.1	2.4	3.8	3.0	2.0	1.8	2.8	4.8	2.3	2.8	2.7
September	1.4	0.7	2.6	1.6	0.6	1.3	2.7	3.7	1.4	2.6	1.9
October	1.8	2.3	3.3	3.0	2.4	4.8	2.3	6.3	1.5	3.0	3.1
November	2.1	1.2	5.6	1.4	1.4	2.6	2.1	2.2	0.6	2.7	2.2
December	2.0	0.8	2.4	0.9	1.5	0.7	1.6	0.4	1.8	2.3	1.4
Total	22.2	24.5	34.1	26.3	17.2	24.3	25.1	28.9	20.8	27.2	25.0
Mean of 5 years			24.9					25.2			
WINTER.	7.0	10.1	7.9	11.5	4.6	6.0	6.3	6.5	4.7	5.2	7.0
Mean of 5 years			8.2					5.7			
SPRING.	5.4	8.2	7.3	9.2	5.4	5.3	9.0	6.1	6.8	7.6	7.1
Mean of 5 years			7.1					7.0			
SUMMER.	8.7	8.5	12.9	11.3	6.6	12.6	9.4	17.4	9.5	11.8	10.9
Mean of 5 years			9.6					12.1			

RAINFALL AT HALIFAX.—Latitude 53° 40′ 00″ N. ; Longitude 1° 53′ 00″ W. ; Height above the Sea 530 feet.

YEARS.	1829.	1830.	1831.	1832.	1833.	1834.	1835.	1836.	1837.	1838.	1839.	1840.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.	Mean of 25 Years.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Jan.	1·5	2.1	1.5	1.1	0.3	6.9	3.3	2.8	3.8	1.2	2.9	5.7	3.5	2.2	4.3	1.8	1.6	3.2	2.1	1.4	5.1	2.6	2.1	5.5	3.9	2. 8
Feb.	1·5	2.1	3.2	1.2	4.5	2.4	4.8	2.5	3.5	2.2	2.0	1.8	1.1	6.9	2.8	3.2	0.7	0.9	2.1	5.3	1.2	3.4	1.3	4.3	1.3	2. 7
March ...	0.1	1.2	3.5	1.9	1.5	3.0	3.5	2.8	1.3	2.7	3.1	0.4	1.7	4.1	1.2	3.8	2.6	2.0	1.5	4.1	1.3	0.6	2.3	0.6	1.4	2. 1
April.....	3·7	3.0	2.1	2.4	3.5	1.3	2.2	2.5	1.3	1.9	0.6	1.0	0.8	0.4	3.6	0.3	1.6	5.5	2.5	1.8	2.1	2.6	1.0	0.5	1.9	2. 0
May	0·7	4.8	1.5	2.2	1.5	0.7	2.5	0.3	1.3	3.7	0.3	4.1	3.4	2.3	3.4	0.3	2.9	0.9	3.9	1.1	1.6	1.5	1.2	1.2	1.3	1.10
June	2·7	5.1	1.7	5.3	6.1	2.1	1.8	3.7	2.2	3.8	4.6	2.7	3.7	1.7	2.6	2.3	2.5	2.2	2.1	4.0	1.4	1.6	4.8	4.4	4.9	3. 2
July	5·7	3.9	4.0	1.6	1.5	6.2	0.8	2.9	3.2	2.8	4.4	3.8	2.7	3.8	3.1	2.0	4.0	1.9	0.8	0.9	3.9	3.8	3.5	2.1	2.4	2. 9
August ..	7·7	2.6	3.6	4.6	3.9	1.7	1.2	1.3	2.0	3.8	3.3	3.0	3.5	1.0	2.5	3.2	5.6	2.1	2.0	4.6	3.8	4.5	2.6	2.4	1.9	3. 1
Sept.....	3·5	5.6	3.2	0.5	2.4	2.6	2.9	3.1	2.7	1.1	4.8	4.6	3.1	2.3	0.6	2.2	1.9	0.9	2.1	3.8	4.1	1.2	1.7	2.7	3.2	2. 7
October	2·4	4.1	4.5	2.7	2.6	1.4	2.8	2.8	5.1	4.7	2.3	1.3	6.0	2.2	7.3	2.4	4.3	4.5	3.2	4.6	3.4	2.3	2.9	5.2	4.2	3. 4
Nov.	2·0	4.5	6.5	3.3	1.5	2.8	2.8	6.1	3.9	2.9	4.7	4.5	3.8	3.8	4.0	2.5	1.9	2.3	2.7	2.0	2.4	2.7	0.8	6.4	2.4	3. 3
Dec.	0·6	2.5	2.7	4.2	5.2	1.2	0.5	4.7	4.6	1.5	2.9	0.4	3.3	1.9	0.3	0.2	5.8	1.1	4.4	2.3	2.9	1.3	1.2	4.9	1.5	2. 5
Totals ...	32·1	41.5	38.0	31.0	34.3	32.6	29.1	35.5	34.9	32.2	35.9	33.4	36.5	26.7	35.7	24.0	35.3	27.5	29.4	37.0	33.3	28.2	24.7	40.1	30.5	32. 7
Mean of 5 years.		35.4				32.8					33.6					30.6					31.3					
WINTER.		6.8	11.7	11.5	12.3	16.0	12.2	8.6	18.1	11.9	9.3	15.1	9.5	16.2	12.8	9.3	5.0	11.8	7.6	13.6	10.6	11.3	7.4	11.8	16.5	11.4
Mean of 5 years.		10.4				13.4					12.6					9.5					11.5					
SPRING.	7·2	14.1	8.8	11.8	12.5	7.1	10.0	9.3	6.1	12.1	8.6	8.2	9.6	8.5	10.7	6.5	9.6	10.5	10.0	11.0	6.4	6.3	9.3	6.6	9.5	9.2
Mean of 5 years.		10.9				8.9					9.1					9.5					7.5					
SUMMER.	19·3	16.2	15.3	9.4	10.4	11.9	7.7	10.1	13.0	12.4	14.8	12.7	15.3	9.4	13.5	9.8	15.8	9.4	8.1	13.9	15.2	11.8	10.7	12.4	11.7	12.4
Mean of 5 years.		14.1				11.0					13.1					11.4					12.3					

RAINFALL OF BELGIUM, GERMANY, SWITZERLAND, ITALY, FRANCE & FRENCH COLONIES.

Place.	Lat. N.	Lon. E.	Hght.	Rain.	No. of Yrs.
	dg.m	dg.m	feet.	in.	
Brussels	50. 51	4. 22	279	29. 0	10
Maestricht	50. 51	5. 37	...	27. 7	20
Louvain	50. 54	4. 41	...	28. 6	12
Liège	50. 25	5. 32	...	29. 6	4
Alost	50. 56	4. 1	...	29. 5	6
Ghent	51. 3	3. 44	...	30. 6	13
St. Trond	50. 50	5. 11	...	27. 2	3
Namur	50. 24	4. 51	...	22. 3	2
Stettin	53. 35	14. 34	71	19. 4	10
Lubeck	53. 52	10. 42	...	20. 7	6
Kiel	54. 14	10. 8	...	25. 2	6
Emden	53. 22	7. 11	...	25. 4	5
Lunemburgh	53. 15	10. 24	...	22. 7	5
Breslau	51. 7	17. 2	484	16. 9	10
Rostock	54. 5	12. 9	...	18. 2	5
Schöneberg	54. 13	18. 7	821	22. 9	7
Poel	53. 59	11. 26	21	14. 0	5
Schönberg	53. 51	10. 56	...	22. 1	5
Hinrichsagen	53. 28	13. 29	...	21. 1	10
Schwerin	53. 36	11. 25	166	20. 6	5
Arys	53. 48	21. 56	480	21. 6	10
Münster	51. 58	7. 38	207	27. 6	5
Wustrow	54. 21	12. 23	38	13. 3	5
Danzig	54. 21	18. 41	30	21. 0	6
Hanover	52. 22	9. 45	...	22. 4	3
Putbus	54. 22	13. 35	174	21. 6	7
Cöslin	54. 12	16. 15	128	23. 8	10
Klausthal	51. 45	10. 23	800	48. 5	3
Königsberg	54. 43	20. 29	72	24. 8	10
Frankfort-o.-O.	52. 40	14. 33	140	21. 3	10
Salzwedel	52. 49	11. 24	...	22. 8	9
Berlin	52. 30	13. 23	154	22. 0	10
Frankfort-o.-M.	50. 6	8. 42	352	16. 4	3
Potsdam	52. 23	13. 4	...	20. 3	10
Bonn	50. 44	7. 6	185	26. 3	4
Posen	52. 20	17. 5	...	20. 0	10
Salzuflen	52. 5	8. 45	...	23. 6	6
Cleves	51. 47	6. 9	184	30. 4	10
Paderborn	51. 44	8. 43	357	28. 0	9
Gutersloh	51. 54	8. 23	266	28. 2	10
Lingen	52. 31	7. 20	...	23. 9	3
Brocken	51. 48	10. 37	3740	46. 6	6
Torgau	51. 34	13. 0	310	22. 6	10
Heiligenstadt	51. 24	10. 12	858	25. 3	10
Ballenstädt	51. 43	11. 15	300	36. 6	7
Görlitz	51. 9	12. 28	582	26. 1	10
Aachen (Aix)	50. 46	6. 5	586	28. 4	4
Zechen	...	...	...	23. 3	10
Mühlhausen	51. 13	10. 27	685	17. 3	7
Crefeld	51. 17	6. 38	...	26. 9	10
Erfurt	50. 59	11. 4	677	20. 8	10
Gotha	50. 56	10. 43	1013	26. 6	7
Ziegenrück	50. 37	11. 40	...	25. 4	6
Arnstadt	50. 50	10. 48	568	21. 0	26
Cologne	50. 55	6. 55	156	24. 0	10
Neisse	50. 28	17. 20	614	21. 0	3
Halle	51. 29	11. 55	362	19. 7	7
Ratibor	50. 22	18. 14	707	23. 7	10
Boppard	50. 14	7. 36	321	26. 1	10
Neunkirchen	49. 20	7. 11	843	25. 2	7
Kreuznach	49. 50	7. 51	376	19. 5	7
Treves	49. 48	6. 38	460	27. 1	9
Stadil	56. 12	8. 15	...	33. 4	6
Traneberg	55. 50	10. 47	...	22. 7	6
Vedersö	56. 15	10. 13	...	29. 0	6
Copenhagen	55. 40	12. 37	...	23 0	39
Geneva	46. 12	6. 08	1335	31. 6	12

Place.	Lat. N.	Lon. E.	Hght.	Rain.	No. of Yrs.
	dg.m	dg.m	feet.	in.	
Gt. St. Bernard	45. 50	7. 15	8,200	48. 1	10
Ditto	...	...	...	59. 7	32
Turin	45. 04	7. 40	820	38. 6	4
Florence	43. 41	11. 15	234	35. 9	8
Rome	41. 54	12. 28	168	30. 2	40
Naples	40. 51	14. 15	246	41. 8	9
Milan	45. 30	9. 14	459	39. 5	80
Trieste	45. 42	13. 44	...	46. 4	10
Venice	45. 42	12. 20	21	34. 1	19
Altamura	40. 48	16. 32	746	24. 2	8
Ariano	41. 6	15. 2	2,429	33. 1	11
Bologna	44. 30	11. 20	290	20. 6	18
Brescia	45. 30	10. 14	501	49. 2	11
Cagliari	39. 18	7. 02	330	71. 5	3
Camajore	43. 54	10. 20	112	54. 2	40
Feltre	46. 0	11. 56	846	70. 0	10
Goritza	45. 54	13. 38	283	64. 4	6
Nice	43. 42	7. 20	64	55. 2	20
Nicolosi (Etna)	37. 30	15. 2	2,312	26. 1	8
Palermo	38. 6	13. 20	261	22. 8	24
Parma	44. 48	10. 20	160	31. 6	14
Sienna	43. 18	11. 20	1,142	37. 4	10
Tolmezzo	46. 24	13. 2	1,000	95. 9	25
Udine	46. 4	13. 16	359	62. 1	40
Verona	45. 24	11. 2	213	36. 8	36
Paris	48. 50	2. 20	205	23. 1	20
Versailles	48. 48	2. 7	...	22. 0	7
Rouen	49. 27	1. 11	130	33. 7	10
Metz	49. 7	6. 10	597	25. 5	22
Angers	47. 28	0. 34 w	154	30. 9	3
La Chapelle	49. 46	1. 8	455	32. 1	9
Cambrai	50. 15	3. 14	213	22. 8	2
Saint Lo	49. 7	1. 10 w	138	31. 3	3
Cherbourg	49. 39	1. 38 w	...	39. 7	2
Brest	48. 24	4. 29 w	230	38. 8	30
Nantes	47. 11	1. 35 w	...	27. 0	5
Bordeaux	44. 48	0. 32 w	...	29. 7	10
Toulouse	43. 36	1. 28	637	22. 6	10
Goersdorff	48. 57	...	748	37. 6	9
Saulsai	...	...	...	33. 5	7
Privas	44. 44	4. 36	902	50. 5	7
Viviers	44. 29	4. 36	187	33. 5	10
Marseilles	43. 18	5. 22	149	18. 2	8
Alais	44. 7	4. 4	551	39. 0	34
Borbn. les Bns.	47. 58	5. 46	1,089	20. 7	4
Vesoul	47. 38	6. 14	784	22. 6	6
Gray	47. 24	5. 39	768	33. 7	6
Dijon	47. 14	5. 5	869	29. 0	6
Fort de Joux	...	...	3,284	38. 8	6
Montbéliard	47. 30	6. 50	1,273	18. 3	6
Besançon	47. 13	6. 2	1,270	40. 0	6
Dôle	47. 4	5. 30	751	35. 4	6
Châlons	48. 57	4. 21	594	23. 4	42
Lons-le-S'lnier	46. 40	5. 40	856	45. 2	5
Bourg	46. 10	5. 12	918	39. 0	6
Lyons	45. 40	4. 50	598	31. 3	6
,,	...	...	640	28. 4	4
Syam	46. 55	5. 54	1,854	67. 5	4
Rodez	44. 21	2. 34	...	40. 6	6
Algiers	36. 47	3. 4	131	37. 0	10
Oran	35. 44	0. 40 w	161	22. 1	2
Mostaganem	35. 55	0. 5	374	22. 0	1
Oviedo (Spain)	43. 18	5. 49 w	800	111. 1	1
Havannah	23. 9	82 23w	...	50. 2	2
Cayenne	4. 56	52. 12w	...	138. 3	6
Santa Fé	4. 35	74. 15w	...	74. 8	1
St. Benoit	21. 05	55. 40	...	162. 3	3

RAINFALL OF AUSTRIAN EMPIRE.

TABLE OF MEAN ANNUAL FALL OF RAIN,

AND TEMPERATURE OF VARIOUS STATIONS,

Showing their latitude, longitude, and height above the sea level, with the number of years on which the mean has been taken.

NOTE.—The column of No. of Years refers only to the Rainfall. Where observations for the two years were not quite complete, the result is marked (*).

Place.	Lat. N.	Long. E.	Height.	Mean Temp.	Rain.			No. of Years.	Province.
					Max. Fall in 24 hrs. 1853-54.	Days.	Mean.		
	deg.m	deg m	feet.	Fah.	inchs.		inchs.	yrs.	
Koniggratz	50. 12	15. 50	762	45. 4	...	...	23. 2	3	Bohemia.
Hohenelbe	50. 35	17. 54	1,493	43. 6	...	...	27. 4	2	,,
Rzeszow	50. 03	12. 00	601	...	1. 9	170	29. 1	2	,,
Cracow	50. 04	19. 51	710	48. 8	1. 5*	196	33. 1	5	Gallicia.
Senftenberg	50. 05	16. 30	1,374	44. 8	2. 3	170	35. 9	5	Bohemia.
Trantenau	50. 32	15. 55	1,365	...	1. 0*	164	43. 6	1	,,
Leipa	50. 35	14. 30	831	46. 9	1. 2	147	23. 9	3	,,
Prague	50. 05	14. 24	684	49. 2	1. 1	101	15. 1	47	,,
Bodenbach	50. 46	14. 10	466	46. 2	1. 1	123	24. 1	5	,,
Pürglitz	50. 02	14. 00	1,112	46. 5	2. 3	130	20. 0	5	,,
Schössl	50. 27	13. 30	1,067	46. 9	1. 0	113	19. 9	4	,,
Lemberg	49. 50	24. 05	926	45. 7	1. 4*	172	25. 4	3	Gallicia.
Leutschau	49. 01	20. 37	1,859	...	1. 7*	140	27. 2	1	Hungary.
Kesmark	49. 08	20. 27	232	...	2. 3*	100	26. 5	1	,,
Saybusch	49. 39	19. 08	1,131	...	1. 5*	140	31. 8	1	,,
Oderberg	49. 54	18. 20	711	...	2. 0*	129	25. 9	1	Moravia.
Brünn	49. 11	16. 36	696	49. 7	1. 9	152	19. 2	5	,,
Deutschbrod	49. 36	15. 34	2,046	46. 4	1. 7	117	21. 5	5	Bohemia.
Czaslau	49. 57	15. 22	805	48. 7	1. 1	102	18. 9	4	,,
Strakonitz	49. 16	13. 53	1,374	47. 8	1. 9*	181	26. 3	1	,,
Winterberg	49. 04	13. 46	1,082	...	...	...	31. 8	3	,,
Pilsen	49. 45	13. 23	1,054	47. 2	1. 0*	115	16. 0	5	,,
Czernovitz	48. 17	26. 10	728	...	3. 8	116	24. 9	2	Gallicia.
Stanislau	48. 55	24. 45	716	44. 4	1. 5*	118	24. 3	47	,,
Schemnitz	48. 27	18. 55	1,955	45. 5	1. 9	108	36. 4	2	Hungary.
Smecna	...	...	...	45. 3	...	170	16. 8	3	,,
Vienna	48. 12	16. 21	639	50. 2	1. 6	144	19. 6	10	Austria.
Linz	48. 18	14. 18	780	...	1. 6	127	22. 7	3	,,
Kremmsmünster	48. 03	14. 07	1,259	46. 1	1. 5	144	36. 3	32	,,
Wallendorf	47. 09	24. 38	1,246	...	1. 5	151	29. 2	2	Transylvania.
Debreczin	47. 32	21. 35	435	...	1. 7*	80	24. 7	1	Gallicia.
Gran	47. 47	18. 44	409	...	2. 6*	93	15. 0	1	Hungary.
Admont	47. 35	14. 25	1,987	...	2. 8	136	46. 6	2	Styria.
Aussee (Markt)	47. 37	13. 48	2,147	...	...	133	50. 1	1	,,
Alt Aussee	47. 39	14. 00	3,093	...	2. 8*	184	69. 5	2	,,
St. Peter	47. 02	15. 38	4,013	42. 0	3. 0	121	46. 5	3	,,
Strabenbach	...	...	...	...	...	...	46 3	2	,,
Salzburg	47. 48	13. 02	1,431	45. 7	1. 3*	146	43. 7	5	Austria.
Grätz	47. 04	15. 27	1,150	49. 0	...	135	31. 2	9	Styria.
Bregenz	47. 30	9. 41	1,348	...	2. 6	150	48. 2	2	Tyrol.
Fünfkirchen	46. 05	11. 23	594	52. 7	1. 4*	132	17. 1	1	,,
Cilli	46. 14	15. 18	767	...	2. 1	133	46. 5	2	Styria.
St. Paul	46. 43	14. 35	1,290	44. 8	1. 5	116	27. 7	2	Illyria.
Laibach	46. 03	14. 32	939	...	4. 8	140	62. 9	2	,,
Althofen	46. 52	14. 29	2,433	44. 6	2. 2	114	30. 0	4	,,
Klagenfurt	46. 37	14. 19	1,444	46. 0	1. 6	117	38. 9	5	,,
Seifnitz	46. 27	14. 18	2,678	...	3. 0	100	49. 1	1	,,
St. Magdalena	46. 00	14. 07	2,799	...	2. 4*	99	49. 2	1	,,
Tröpolach	46. 37	14. 20	1,945	...	4. 5	136	61. 3	2	,,
Obervellach	46. 54	13. 10	2,147	...	3. 4	132	35. 5	2	,,
St. Jacob	46. 41	13. 00	3,092	46. 2	1. 6	121	37. 3	2	,,
Lienz	46. 49	12. 48	2,154	...	1. 8*	117	29. 9	1	Tyrol.
Kronstadt	45. 39	25. 35	1,879	48. 1	1. 9	144	28. 7	3	Transylvania.
Hermannstadt	45. 47	24. 09	1,387	49. 0	1. 3	143	41. 0	3	,,

RAINFALL OF BELGIUM.

DETAILS FOR BRUSSELS.

Latitude 50° 51′ North; Longitude 4° 22′ East; Height above Sea 262 feet;

With other places; from M. QUETELET's Returns.

Period.		Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Brussels	1841	3.1	0.9	1.0	1.5	2.7	2.1	5.5	2.1	1.6	3.8	3.0	3.4	30.7
	1842	0.6	1.0	4.5	1.4	1.9	1.4	2.9	2.7	3.2	1.7	2.6	0.8	24.7
	1843	3.9	3.6	0.9	2.1	2.1	2.2	2.6	1.9	1.4	6.7	3.4	0.8	31.6
	1844	2.6	3.4	3.4	0.6	3.2	1.2	5.6	4.6	1.9	1.4	2.9	0.8	31.6
	1845	1.7	1.8	1.7	1.5	4.3	1.4	3.3	3.9	3.1	1.5	2.4	5.2	31.8
	1845	3.4	1.6	3.0	3.3	0.5	1.5	1.7	2.4	2.4	1.3	1.6	2.2	24.9
	1847	1.3	2.0	1.6	2.0	1.2	2.1	0.8	5.1	2.3	2.3	1.4	1.8	23.9
	1848	0.3	3.5	3.5	4.1	0.8	2.8	2.2	5.3	1.3	2.5	2.8	2.2	31.3
	1849	2.0	1.3	1.1	2.7	2.3	1.0	3.4	1.9	2.3	3.6	1.9	3.4	26.9
	1850	2.8	2.5	1.4	1.9	1.1	1.7	4.3	8.1	2.2	1.8	2.3	2.8	32.9
	Mean	2.2	2.2	2.2	2.1	2.0	1.7	3.2	3.8	2.2	2.7	2.4	2.3	29.0
Mean daily fall		.071	.072	.068	.064	.060	.078	.087	.098	.079	.084	.083	.073	
,, No. of Days Rain		14.0	13.2	15.2	14.6	13.9	14.8	16.1	15.7	14.5	17.5	16.7	15.2	181.4
Greatest fall in 24 hours in each month.	1845	0.47	0.27	0.35	0.28	1.09	0.43	0.62	0.92	0.81	0.70	0.52	1.53	
	1846	0.67	0.29	0.49	0.58	0.15	0.61	0.84	0.72	0.78	0.30	0.44	0.39	
	1847	0.21	0.51	0.55	0.37	0.32	0.39	0.35	1.86	0.46	0.45	0.25	0.41	
	1848	0.07	0.47	0.60	0.77	0.71	0.40	0.90	1.06	0.44	0.52	0.28	0.44	
	1849	0.36	0.82	0.17	0.35	1.20	0.76	0.52	0.28	0.39	0.62	0.48	0.49	
	1850	0.57	0.40	0.57	0.22	0.18	0.60	0.75	3.07	0.60	0.70	0.37	0.87	
Mean of 17 years		0.47	0.46	0.51	0.47	0.50	0.75	0.75	0.94	0.61	0.64	0.60	0.49	
Maestricht	Mean of 20 years	1.75	1.61	1.90	2.04	2.15	2.70	3.01	3.13	2.29	1.75	2.72	2.64	27.69
Louvain	1844	2.9	3.3	3.3	1.0	3.4	0.9	5.4	4.8	2.4	1.1	2.5	0.6	31.6
	1845	1.2	1.8	1.6	1.1	4.2	1.5	2.6	3.8	3.3	1.1	2.6	4.5	29.3
	1846	3.4	1.3	2.7	3.4	0.9	1.5	1.7	1.1	2.4	1.3	1.6	2.1	23.4
	1847	1.4	2.0	1.3	1.6	0.9	2.9	0.6	4.0	2.0	2.7	1.3	1.5	22.2
	1848	0.0	3.2	2.7	3.9	0.6	3.8	1.9	4.4	1.3	2.4	2.7	1.9	28.8
	Mean of 12 years	2.22	2.14	1.97	2.00	2.15	3.09	2.68	3.05	2.31	2.34	2.80	1.82	28.57
Liege	1848	0.00	4.33	3.53	4.96	0.79	2.44	2.30	5.39	1.87	3.46	2.64	1.34	33.05
	1849	2.70	1.95	0.16	2.18	1.37	1.46	3.80	1.50	1.53	4.00	1.44	3.04	25.19
	1850	3.67	2.93	1.85	2.32	2.25	2.43	2.31	5.72	1.45	1.72	2.30	2.52	31.47
Mean of 4 years		2.12	3.07	1.71	3.05	1.51	2.17	2.36	4.50	2.01	3.12	1.84	2.16	29.62
Alost	1836	3.5	1.9	5.7	2.2	1.5	3.6	4.0	0.4	3.7	3.4	3.6	1.7	35.2
	1837	2.2	3.1	1.0	2.7	1.9	1.0	3.4	2.1	1.8	1.0	5.4	1.3	27.1
	1838	0.2	1.0	1.4	1.8	2.6	4.6	3.5	3.2	2.0	2.7	2.8	1.0	26.8
	1839	4.0	2.5	1.3	1.3	1.2	6.6	2.5	3.9	2.7	1.4	2.3	4.7	34.4
	1840	4.1	1.6	0.6	0.5	2.6	2.4	3.5	3.8	3.3	3.0	4.3	1.4	31.1
	Mean of 6 years	2.77	1.95	1.85	1.67	2.06	3.36	2.89	2.38	2.82	2.55	3.36	1.80	29.46
Ghent	1846	3.50	1.25	3.05	3.11	1.52	1.41	2.29	1.27	1.95	1.35	1.61	2.76	25.11
	1847	1.42	2.15	1.89	1.65	1.10	2.70	1.72	4.68	2.30	2.52	1.62	1.65	25.40
	1848	0.33	3.18	2.96	3.12	0.35	3.13	2.32	4.56	1.82	1.85	3.02	1.86	28.50
	1849	1.92	1.93	0.93	3.36	2.20	0.72	3.30	1.88	2.90	4.09	2.02	4.34	29.59
	1850	3.20	2.27	2.08	2.16	1.07	2.04	4.06	7.59	1.27	3.24	2.25	1.86	33.09
Mean of 13 years		2.41	1.97	2.06	1.99	2.11	2.72	3.39	3.59	2.72	2.88	2.52	2.21	30.57
St. Trond	1848	0.23	3.23	2.02	4.19	0.18	3.49	1.66	4.70	1.16	3.62	1.63	1.46	27.57
	1849	2.36	1.37	1.23	3.05	1.28	0.89	3.02	1.03	1.75	4.03	1.15	4.14	25.30
	1850	3.38	2.71	1.06	2.56	1.49	1.18	2.24	7.17	0.98	1.89	1.93	1.81	28.40
	Mean	1.99	2.44	1.44	3.27	0.99	1.85	2.31	4.30	1.30	3.25	1.57	2.47	27.18
Namur	1849	2.36	1.33	1.40	2.48	1.07	1.61	2.08	0.95	0.64	2.39	1.58	2.33	20.22
	1850	2.58	2.31	1.41	2.15	0.78	0.68	2.65	5.96	0.99	1.26	1.57	2.14	24.48

RAINFALL OF GERMANY.

DETAILS OF MONTHLY FALL.

Period.		Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Stettin.....	1848	0.5	2.1	1.5	1.5	2.1	2.4	0.8	1.5	1.5	2.5	2.4	0.8	19.6
	1849	1.8	1.2	1.5	2.4	1.2	0.9	1.0	0.7	0.5	1.6	1.9	1.0	15.7
	1850	1.4	1.8	1.1	1.6	2.3	1.6	2.6	0.8	1.5	2.9	1.5	1.3	20.4
	1851	0.5	0.4	1.7	2.6	1.6	2.1	3.4	2.7	2.7	1.8	3.2	1.1	23.8
	1852	1.1	1.6	0.3	0.7	1.6	1.9	1.2	4.4	1.8	1.4	1.1	2.3	19.4
	1853	1.4	2.2	0.8	1.6	1.7	4.2	2.2	4.0	1.9	0.8	0.4	0.2	21.4
	1854	1.5	1.1	0.4	0.6	1.3	4.8	0.8	2.8	1.7	1.0	1.7	2.8	20.5
	1855	1.3	0.9	1.1	1.1	1.8	0.9	3.8	6.0	0.7	1.6	0.8	1.2	21.2
	1856	0.9	0.9	2.3	1.9	2.6	5.4	2.1	4.7	1.3	0.4	1.6	1.2	25.3
	1857	0.9	0.2	0.9	1.7	0.5	0.6	1.8	1.4	1.5	0.5	1.0	0.7	11.7
	Mean	1.1	1.2	1.1	1.6	1.7	2.5	2.0	2.9	1.5	1.4	1.6	1.3	19.9
Lubeck.....	1848	1.2	2.6	1.2	2.4	0.5	4.0	1.7	3.7	0.9	1.8	2.3	1.5	23.8
	1849	2.0	0.9	1.2	1.1	1.2	2.1	2.7	1.9	1.4	3.3	0.5	1.6	19.9
	1850	0.7	1.8	0.4	1.5	1.8	1.6	2.9	1.6	2.4	3.0	2.5	1.1	21.3
	1851	0.9	1.0	1.7	2.2	1.8	1.8	2.6	3.3	1.5	1.6	2.2	0.3	20.9
	1852	1.4	2.0	0.5	0.4	1.6	3.2	0.7	1.9	3.3	2.0	1.9	1.8	20.7
	1853	1.0	0.3	0.5	1.4	0.9	2.7	4.8	2.1	1.1	2.2	0.9	0.3	17.8
	Mean	1.0	1.4	1.1	1.5	1.3	2.6	2.6	2.5	1.6	2.3	1.7	1.1	20.7
Kiel	1851	...	...	...	...	2.0	2.5	1.5	2.2	1.5	2.0	2.4	2.2	...
	1852	3.6	3.2	1.1	1.0	1.6	3.1	0.8	3.1	3.1	4.9	3.0	4.1	32.6
	1853	2.7	1.7	1.6	2.7	1.6	4.9	4.0	2.4	1.3	2.5	0.7	1.5	27.6
	1854	2.7	1.2	1.5	0.5	2.4	3.0	2.3	3.2	3.0	1.3	2.4	3.1	26.6
	1855	1.1	1.3	1.7	1.3	3.1	2.2	4.0	2.9	0.9	2.8	1.1	1.4	23.8
	1856	2.3	1.7	0.1	1.9	2.5	1.9	2.2	3.6	3.5	0.3	1.8	2.3	24.1
	1857	0.9	0.4	1.6	1.1	0.4	0.9	4.6	0.5	3.5	1.1	0.6	1.0	16.6
	Mean	2.2	1.6	1.3	1.4	1.9	2.7	3.0	2.6	2.6	2.1	1.6	2.2	25.2
Emsden	1853	1.8	2.4	0.3	0.9	0.9	4.4	5.6	2.3	2.2	2.2	0.3	3.3	26.6
	1854	1.3	1.7	0.3	0.8	1.8	2.0	3.0	3.2	2.5	3.3	2.9	3.0	25.8
	1855	1.0	1.5	1.0	0.7	2.3	4.0	3.5	3.8	0.6	5.2	1.4	1.7	26.7
	1856	2.7	1.7	0.4	1.2	4.0	1.2	2.6	3.6	3.3	0.5	3.6	2.5	27.3
	1857	2.5	0.3	1.7	1.8	1.2	2.0	5.4	1.3	2.1	0.7	0.6	1.1	20.7
	Mean	1.9	1.5	0.7	1.1	2.0	2.7	4.0	2.9	2.1	2.4	1.8	2.3	25.4
Lunemburgh	1853	1.3	1.3	1.2	1.8	1.0	6.7	3.5	2.7	1.3	2.6	0.6	0.5	24.5
	1854	1.3	2.6	0.3	0.6	3.5	1.8	1.6	2.8	1.9	2.4	1.5	4.4	24.7
	1855	1.3	0.8	1.4	1.3	4.4	1.9	5.9	2.2	0.5	2.3	1.3	1.4	24.7
	1856	1.5	1.3	0.1	2.3	2.3	1.8	3.3	4.4	1.5	1.5	3.1	2.4	25.5
	1857	1.2	0.5	1.1	2.2	1.9	1.5	1.2	1.3	1.1	0.7	0.6	0.8	14.1
	Mean	1.3	1.3	0.8	1.7	2.6	2.7	3.1	2.7	1.3	1.9	1.4	1.9	22.7
Breslau	1848	0.5	0.9	0.6	1.5	0.3	4.3	1.5	1.0	0.6	1.1	1.5	0.1	13.9
	1849	1.1	0.8	1.0	0.6	1.7	1.8	1.3	1.8	0.5	2.7	0.7	1.2	15.3
	1850	0.9	1.1	0.1	1.3	1.3	3.1	3.0	1.8	1.0	2.8	1.2	0.5	18.1
	1851	0.6	0.3	0.7	1.5	0.9	1.5	2.8	2.0	2.1	1.6	1.8	0.8	16.6
	1852	0.8	1.1	1.3	0.9	1.1	1.8	0.9	1.4	0.6	0.6	1.2	0.3	12.0
	1853	0.8	0.7	1.5	0.9	2.5	6.0	2.5	0.8	2.3	1.1	0.2	0.5	19.8
	1854	1.4	0.9	0.7	1.0	2.0	4.1	2.3	8.4	0.6	1.9	1.3	1.4	26.0
	1855	0.5	1.7	2.1	1.1	2.4	1.4	1.9	3.7	2.1	1.3	0.8	0.4	19.4
	1856	0.6	1.7	0.2	0.4	1.0	2.4	2.0	1.7	1.4	0.1	1.5	0.7	13.7
	1857	0.8	0.3	0.7	1.7	0.6	1.5	3.7	1.4	1.1	1.0	0.9	1.0	14.7
	Mean	0.8	0.9	0.9	1.1	1.4	2.8	2.2	2.4	1.2	1.4	1.1	0.7	16.9
Rostock	1853	0.7	1.4	0.6	1.5	0.5	0.5	1.5	2.1	1.7	1.1	0.6	0.1	12.3
	1854	1.8	1.2	0.3	0.5	1.9	1.3	2.7	2.8	2.2	2.3	1.7	4.3	23.0
	1855	1.0	0.4	1.5	1.6	2.2	1.1	4.5	1.6	1.2	1.9	0.9	1.2	19.1
	1856	2.1	1.7	0.0	3.0	2.0	2.3	2.3	4.9	2.2	1.0	1.1	1.9	24.5
	1857	1.3	0.4	1.0	1.8	0.0	0.7	1.9	1.6	1.1	0.6	0.5	1.0	11.9
	Mean	1.4	1.0	0.7	1.7	1.3	1.2	2.6	2.6	1.7	1.4	0.9	1.7	18.2

RAINFALL OF GERMANY.

DETAILS OF MONTHLY FALL.

Period.		Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Schöneberg..	1851	1.1	1.6	3.2	1.3	2.4	2.9	1.8	3.9	1.9	1.8	3.7	2.0	27.6
	1852	1.4	1.0	0.9	0.7	1.5	1.5	0.8	4.0	2.7	2.1	1.6	2.3	20.9
	1853	1.0	2.2	0.6	2.2	1.7	2.9	2.1	5.0	2.7	0.6	0.5	0.3	21.8
	1854	2.5	2.3	1.8	0.8	1.1	1.6	2.7	4.3	2.5	1.7	3.6	1.9	26.8
	1855	1.5	0.2	1.3	0.3	3.8	1.9	10.7	1.7	1.5	3.4	1.1	0.9	28.3
	1856	2.6	1.3	0.4	0.4	3.6	4.3	3.1	3.4	1.1	0.8	0.7	0.4	22.1
	1857	0.5	0.1	0.4	0.6	0.6	0.7	1.1	1.3	3.0	1.4	0.9	1.9	12.5
	Mean	1.5	1.3	1.2	0.9	2.1	2.3	3.2	3.4	2.2	1.7	1.7	1.4	22.9
Pool	1853	1.3	0.8	1.4	1.9	0.5	1.0	4.1	1.7	1.3	1.4	0.9	0.1	16.4
	1854	1.5	0.9	0.8	1.0	2.0	2.5	2.4	2.4	1.5	1.5	0.5	2.8	19.8
	1855	0.9	0.4	0.3	0.4	2.0	1.8	2.6	1.2	0.4	2.1	0.4	0.4	11.9
	1856	1.2	1.0	0.1	0.8	0.8	0.9	1.5	4.5	1.2	0.3	1.1	0.7	14.1
	1857	0.4	0.3	0.4	0.9	0.0	0.8	1.8	1.1	0.4	0.5	0.8	0.5	7.9
	Mean	1.1	0.7	0.6	1.0	1.1	1.4	2.5	2.2	0.9	0.9	0.7	0.9	14.0
Schönberg ...	1853	1.8	2.1	2.2	2.4	1.1	4.2	4.0	2.2	1.5	1.8	0.7	0.7	24.7
	1854	1.8	1.8	0.5	0.6	2.9	1.8	3.2	3.3	1.7	2.0	0.9	3.8	24.3
	1855	1.6	0.7	2.2	1.3	3.1	2.2	3.4	1.9	0.5	1.5	1.3	2.0	21.7
	1856	2.0	1.8	0.1	2.3	1.9	2.3	3.3	4.6	2.0	1.4	2.1	0.7	24.5
	1857	1.7	0.3	1.7	1.4	0.7	0.8	3.5	1.1	1.1	0.7	0.8	1.4	15.2
	Mean	1.8	1.3	1.3	1.6	1.9	2.3	3.5	2.6	1.4	1.5	1.2	1.7	22.1
Hinrichagen	1848	0.1	2.3	1.9	3.5	0.9	2.3	1.0	2.6	1.6	4.0	2.8	1.5	24.5
	1849	3.6	1.3	1.4	0.6	1.5	0.6	2.9	1.4	0.7	2.4	1.7	2.0	20.1
	1850	1.3	2.5	0.9	1.3	2.5	1.9	2.3	1.6	2.5	4.1	2.4	1.4	24.6
	1851	0.6	0.5	1.6	3.6	2.2	2.2	2.7	3.1	2.1	1.3	4.2	0.3	24.4
	1852	1.7	1.9	0.1	0.6	2.8	3.9	0.6	1.0	3.7	1.8	2.0	1.5	21.6
	1853	1.1	3.3	1.9	1.9	1.0	2.8	4.1	3.2	2.0	0.5	0.9	0.1	22.8
	1854	0.6	0.6	0.7	0.8	1.3	2.9	2.3	5.7	1.7	1.3	1.7	3.6	23.2
	1855	1.5	0.6	1.2	1.0	2.7	1.1	4.5	2.6	0.8	1.7	0.8	1.2	19.7
	1856	0.6	1.1	0.4	1.0	1.9	2.5	2.8	5.3	0.8	0.7	0.8	2.0	19.9
	1857	0.4	0.2	0.6	2.0	0.4	0.4	1.2	1.3	1.8	0.4	0.7	1.2	10.6
	Mean	1.1	1.4	1.1	1.6	1.7	2.1	2.4	2.8	1.8	1.8	1.8	1.5	21.1
Schwerin	1853	1.5	2.8	1.7	2.0	0.5	3.7	4.0	1.5	1.5	1.3	0.9	0.5	21.9
	1854	1.7	1.3	0.5	0.6	2.3	2.2	1.9	2.5	1.7	2.2	1.2	3.4	21.5
	1855	1.2	0.7	2.1	1.1	3.4	1.1	4.7	2.4	0.7	1.4	1.5	1.3	21.6
	1856	2.2	1.4	0.2	2.5	1.6	2.2	2.6	3.8	2.3	1.4	1.8	2.5	24.5
	1857	1.7	0.5	1.4	2.1	0.4	0.7	1.5	1.3	1.1	0.5	1.1	1.3	13.6
	Mean	1.7	1.3	1.2	1.7	1.6	2.0	2.9	2.3	1.5	1.3	1.3	1.8	20.6
Arys	1848	0.7	2.0	1.0	0.6	1.4	2.6	3.2	2.6	2.8	1.2	2.3	1.4	21.8
	1849	2.0	1.9	1.2	1.2	1.3	2.3	3.0	2.0	1.9	2.3	1.7	1.8	22.6
	1850	2.7	1.9	1.1	0.6	1.7	3.1	2.5	2.8	2.7	4.8	2.6	1.5	28.0
	1851	0.8	1.8	1.7	1.2	2.8	4.2	3.5	2.5	2.3	1.4	2.5	0.9	25.6
	1852	1.1	1.1	0.2	0.4	1.9	4.2	1.6	3.0	1.9	1.0	1.6	2.1	20.1
	1853	0.6	0.8	0.8	1.7	1.2	3.6	6.4	2.9	2.2	0.4	0.5	0.1	21.2
	1854	1.3	0.7	1.1	1.3	2.3	2.7	2.6	3.4	1.4	1.2	1.1	0.8	19.9
	1855	1.1	0.4	2.1	1.1	2.8	3.0	5.2	2.6	1.8	3.9	0 5	0.8	25.3
	1856	1.5	1.4	0.4	1.3	3.7	1.0	1.2	3.0	0.6	0.4	1.6	1.5	17.6
	1857	0.5	0.2	0.5	1.4	1.2	2.3	2.7	2.3	0.4	0.1	0.3	1.7	13.6
	Mean	1.2	1.2	1.0	1.1	2.0	2.9	3.2	2.7	1.8	1.7	1.5	1.3	21.6
Münster	1853	3.3	1.9	1.4	3.9	1.1	4.4	2.7	3.4	3.2	2.5	0.1	1.1	29.0
	1854	2.0	2.6	0.4	1.4	5.0	4.0	1.4	2.7	1.6	3.6	2.2	5.7	32.6
	1855	0.8	1.0	1.8	0.8	3.3	4.5	4.4	1.7	0.7	4.2	1.5	1.3	26.0
	1856	1.9	2.6	0.4	2.5	5.2	3.0	1.8	4.7	2.3	1.2	4.3	2.0	31.9
	1857	2.0	0.1	1.4	1.9	2.2	1.6	3.1	1.8	1.5	1.0	0.8	2.0	18.4
	Mean	2.0	1.6	1.1	2.1	3.4	3.5	2.7	2.9	1.8	2.5	1.8	2.2	27.6

RAINFALL OF GERMANY.

DETAILS OF MONTHLY FALL.

Period.		Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Wustrow	1853	1.2	0.6	0.3	1.9	0.5	1.2	2.2	1.6	1.4	1.2	0.0	0.1	12.2
	1854	1.1	0.2	0.1	0.4	0.8	2.2	2.1	1.7	1.6	0.7	0.7	1.3	12.9
	1855	0.7	0.1	1.1	1.0	2.2	1.1	3.0	0.8	0.6	0.9	1.2	0.3	13.0
	1856	2.0	1.3	0.0	2.1	1.8	2.6	0.9	3.4	1.1	1.7	0.7	1.1	18.7
	1857	0.6	0.1	0.4	2.3	0.0	0.5	2.8	1.1	0.7	0.4	0.6	0 3	9.8
	Mean	1.1	0.5	0.4	1.5	1.1	1.5	2.2	1.7	1.1	1.0	0.6	0.6	13.3
Danzig.....	1851	0.8	0.5	2.2	1.1	2.3	2.0	2.8	2.0	3.8	1.9	3.0	0.7	23.1
	1852	0.7	1.4	0.7	0.5	1.1	2.1	0.3	2.3	2.6	1.7	1.4	1.8	16.6
	1853	0.8	1.8	0.3	1.6	2.1	3.0	2.5	6.0	3.3	0.7	0.5	0.2	22.8
	1854	1.8	1.6	0.5	0.5	2.6	0.8	1.7	3.0	2.5	1.3	3.3	1.4	21.0
	1855	1.6	0.1	1.3	0.4	2.3	1.7	8.2	2.5	1.3	1.7	0.6	1.4	23.1
	1856	1.2	0.9	0.2	1.0	2.9	3.9	1.5	3.2	0.6	0.9	2.4	0. 8	19.5
	1857	0.6	0.1	0.7	1.8	0.6	0.8	1.3	1.4	...	...	...	...	...
	Mean	1.1	0.9	0.8	1.0	2.0	2.0	2.6	2.9	2.3	1.4	1.9	1.1	21.0
Mean Temp.		26.1	31.3	34.1	43.9	52.5	61.0	64.0	63.0	56.0	48.9	37.4	33.5	46.0
Hanover	1855	0.4	0.6	1.4	2.2	2.7	5.2	5.4	1.1	0.4	2.4	0.5	1.0	23.3
	1856	1.2	1.9	0.2	3.3	2.2	2.2	3.6	3.6	1.4	1.1	3.9	5.2	29.8
	1857	1.7	0.1	1.3	1.2	2.2	0.8	2.5	1.7	0.5	0.7	0.4	1.1	14.2
	Mean	1.1	0.9	1.0	2.2	2.4	2.7	3.8	2.1	0.8	1.4	1.6	2.4	22.4
Putbus.....	1851	1.2	1.3	2.1	2.7	1.1	2.0	2.0	2.2	1.5	3.1	2.8	2.5	24.5
	1852	1.7	1.0	0.4	0.7	1.3	3.5	1.4	1.9	3.9	2.5	2.0	2.3	22.6
	1853	1.8	0.8	1.1	2.2	1.6	1.6	2.2	2.4	1.4	1.3	0.4	0.4	17.2
	1854	1.6	1.1	0.7	0.8	1.5	4.5	1.9	5.2	3.7	1.5	2.3	3.9	28.7
	1855	1.3	0.3	1.9	1.4	1.8	2.0	4.6	3.2	1.2	1.7	0.9	2.4	22.7
	1856	1.5	1.3	0.0	1.7	1.1	2.6	2.1	3.6	1.7	1.3	1.5	2.1	20.5
	1857	1.0	0.2	1.1	2.8	0.3	1.2	1.6	3.2	1.1	0.5	0.7	1.0	14.7
	Mean	1.4	0.9	1.0	1.8	1.2	2.5	2.3	3.1	2.1	1.7	1.5	2.1	21.6
Cöslin	1848	1.4	1.3	1.5	2.7	0.6	3.8	1.2	2.5	2.3	2.4	3.6	2.2	25.5
	1849	3.2	2.5	1.8	2.4	1.5	1.7	2.7	2.9	1.8	2.9	4.0	2.0	29.4
	1850	0.9	1.6	0.8	0.7	3.5	3.1	3.4	2.2	4.2	5.2	4.4	1.4	31.4
	1851	0.8	1.3	0.6	1.4	1.7	4.3	2.9	1.0	2.4	2.8	3.8	0.7	23.7
	1852	0.7	1.4	0.7	0.4	2.9	4.7	0.3	2.9	3.5	3.0	1.7	2.7	24.9
	1853	1.3	1.0	0.7	1.6	1.2	1.8	1.3	5.3	2.6	2.2	0.5	0.1	19.6
	1854	1.5	1.1	0.5	0.5	1.0	2.8	1 2	3.2	3 5	1.3	3.5	2.4	22.5
	1855	1.6	0.5	1.3	0.7	2.7	1.2	4.4	4.6	1.9	3.1	1.5	1.5	25.0
	1856	1.3	1.2	0.3	1.2	2.8	4.9	3.4	2.5	1.7	0.8	1.5	1.9	23.5
	1857	1.2	0.5	1.4	1.1	0.5	1.0	1.2	1.4	1.0	1.1	0.9	0.8	12.1
	Mean	1.4	1.3	1.0	1.3	1.8	2.9	2.2	2.8	2.5	2.5	2.5	1.6	23.8
Clausthal ...	1855	3.2	2.6	4.3	5.4	3.7	4 7	11.9	3.6	1.0	6.5	2.5	3.9	53.3
	1856	4.8	7.1	0.9	5.5	3.6	5.1	3.4	10.0	3.9	1.3	12.0	3.5	61.1
	1857	3.3	0.6	4.7	3.4	2.0	1.9	3.8	4.7	1.6	0.7	1.0	3.3	31.0
	Mean	3.8	3.4	3.3	4.8	3.1	3.9	6.4	6.1	2.2	2.8	5.2	3.5	48.5
Königsberg..	1848	0.2	2.5	1.4	1.7	0.8	3.0	1.6	2.5	4.9	2.5	2.4	1.4	24.9
	1849	3.2	2.3	2.1	1.1	0.8	3.1	3.9	2.4	1.3	3.0	2.3	1.8	27.3
	1850	2.0	2.3	1.2	0.4	1.2	2.7	1.7	4.0	4.0	4.6	3.0	2.2	29.3
	1851	1.3	1.8	2.8	1.2	2.6	3.4	2.5	3.8	3.2	2.9	3.3	3.3	32.1
	1852	1.8	3.0	0.9	0.6	0.6	3.5	0.3	2.3	2.0	2.4	3.0	3.0	23.4
	1853	1.1	2.5	0.9	2.2	2.7	1.4	4.0	6.6	2.5	0.8	0.7	0.9	26.3
	1854	1.3	0.7	1.1	1.3	2.3	2.7	2.6	3.4	1.4	1.2	1.1	0.8	19.9
	1855	1.1	0.4	2.1	1.1	2.8	3.0	5.2	2.6	1.8	3.9	0.5	0.8	25.3
	1856	1.5	1.4	0.4	0.8	2.0	5.6	1.7	3.8	1.6	1.4	3.2	2.1	25.5
	1857	1.2	0.5	0.6	1.8	1.2	0.5	1.4	1.0	2.6	0.9	0.8	1.9	14.4
	Mean	1.5	1.7	1.4	1.2	1.7	2.9	2.5	3.2	2.5	2.4	2.0	1.8	24.8
Mean Temp.		23.2	27.0	31.1	41.7	52.2	61.0	63.2	62.1	55.2	47.5	34.9	31.2	44.4

RAINFALL OF GERMANY.

DETAILS OF MONTHLY FALL.

Period.		Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Frankfort-on-Oder	1848	0.4	1.4	2.1	1.8	1.8	2.2	3.8	1.6	2.5	1.5	1.6	0.3	21.0
	1849	1.9	0.7	1.4	2.4	0.8	1.3	1.3	1.2	0.5	1.1	0.6	2.0	15.2
	1850	1.7	2.9	1.0	1.2	1.7	2.0	2.0	2.0	1.6	2.7	3.2	2.0	24.0
	1851	0.8	0.6	3.0	3.9	2.2	1.9	1.5	1.4	1.3	1.0	5.3	0.6	23.5
	1852	1.8	2.2	0.5	0.4	5.0	4.0	0.9	2.4	1.8	1.8	1.0	1.4	23.2
	1853	2.0	1.9	1.4	2.8	0.5	4.9	1.9	2.2	1.4	1.3	0.3	0.4	21.0
	1854	1.0	1.4	0.8	0.6	2.0	4.3	4.7	3.5	1.3	0.8	2.2	4.4	27.0
	1855	0.9	1.3	1.3	1.2	3.1	2.1	7.0	2.5	0.4	1.3	0.4	0.4	21.9
	1856	0.9	1.8	0.5	0.7	2.5	4.5	1.4	5.6	1.6	0.3	2.2	1.1	23.1
	1857	0.8	0.2	0.5	2.0	0.4	0.3	2.5	1.5	2.0	0.8	0.6	1.5	13.1
	Mean	1.2	1.4	1.3	1.7	2.0	2.8	2.7	2.4	1.4	1.3	1.7	1.4	21.3
Salzwedel ...	1848	0.2	2.9	1.4	2.1	0.6	4.6	2.0	4.2	2.7	3.1	2.3	0.7	26.8
	1849	2.1	1.5	1.7	1.3	1.4	1.7	2.4	1.8	3.3	2.1	0.9	2.4	22.0
	1850	1.4	3.0	0.8	0.7	2.0	0.8	1.6	3.0	1.7	2.4	2.7	2.5	22.6
	1851	1.1	0.9	2.9	2.2	2.0	2.7	2.4	3.2	2.2	1.0	3.1	0.3	24.0
	1852	1.9	3.1	0.4	0.4	3.3	3.7	0.7	1.0	3.5	2.5	2.2	1.8	24.5
	1853	2.0	1.2	1.5	1.8	0.8	7.6	...	...	...	...	0.5	0.6	...
	1854	1.5	1.8	0.3	0.6	2.5	2.2	2.3	2.5	1.2	2.6	1.2	4.5	23.2
	1855	1.2	1.8	2.5	1.0	2.6	3.9	5.8	1.8	0.6	2.2	1.1	1.1	25.6
	1856	1.7	1.3	0.3	3.2	2.7	2.1	2.5	2.7	1.2	1.0	2.3	1.8	22.8
	1857	1.5	0.2	1.2	1.6	1.1	0.7	3.4	1.4	1.1	0.4	0.7	0.7	14.0
	Mean	1.5	1.8	1.3	1.5	1.9	3.0	2.6	2.3	1.9	1.9	1.9	1.8	22.8
Berlin	1848	0.3	2.3	1.6	3.2	1.2	5.5	1.0	1.7	2.1	2.1	2.2	0.5	23.7
	1849	0.7	1.7	1.3	2.4	1.1	1.4	1.5	0.8	1.3	0.9	2.4	4.7	17.0
	1850	2.8	3.4	1.2	1.0	2.7	2.0	1.8	1.4	1.0	2.8	2.3	2.1	24.5
	1851	0.9	0.6	2.7	2.7	2.0	1.7	2.2	1.7	2.1	2.3	4.7	1.0	24.6
	1852	1.9	2.6	0.6	0.9	3.5	4.9	1.5	3.2	2.1	1.6	1.5	2.2	26.5
	1853	2.0	2.0	1.4	2.9	1.5	5.2	3.2	2.2	1.1	1.5	0.4	0.6	24.0
	1854	1.5	1.3	0.4	1.0	1.8	4.6	3.5	3.5	1.2	0.8	1.0	4.1	24 7
	1855	0.8	1.7	1.5	1.5	2.5	1.9	6.6	3.0	0.3	1.3	1.1	1.8	24.0
	1856	1.0	1.9	0.3	1.2	2.2	2.4	1.2	3.0	1.2	0.4	1.4	0.9	17.1
	1857	1.1	0.4	1.0	2.5	0.6	1.2	1.4	1.5	0.6	1.0	0.9	1.7	13.9
	Mean	1.3	1.8	1.2	1.9	1.9	3.1	2.4	2.3	1.3	1.5	1.6	1.7	22.0
Mean Temp.		27.7	31.7	38.2	47.5	56.6	63.4	65.8	64.5	58.4	49.9	39.3	35.0	48.2
Potsdam	1848	0.5	1.6	0.9	2.4	1.3	4.0	0.6	2.2	0.6	1.6	2.3	0.[illegible]	18.2
	1849	2.8	1.3	1.4	2.1	1.2	0.7	2.1	1.5	1.8	1.4	0.7	1.6	18.6
	1850	2.0	2.3	0.6	0.6	2.7	1.1	3.0	2.0	1.2	2.0	2.0	1.7	21.2
	1851	0.4	0.6	2.1	3.0	2.0	1.6	1.2	1.6	2.6	1.7	3.0	0.3	20.1
	1852	1.5	2.1	0.4	0.5	3.1	3.9	0.6	1.6	2.0	1.2	1.8	1.5	20.2
	1853	1.2	2.5	1.0	2.7	0.9	5.7	3.0	1.8	1.1	0.7	0.9	0.5	22.0
	1854	0.8	3.0	1.3	0.6	2.1	3.1	3.9	4.7	0.9	0.8	1.5	4.0	26.7
	1855	1.5	2.8	0.9	1.6	2.4	1.1	6.2	2.1	0.3	2.6	0.8	0.6	22.9
	1856	0.7	1.5	0.2	1.3	2.5	2.4	1.8	4.5	1.9	0.3	2.5	0.6	20.2
	1857	0.8	0.2	0.7	2.4	0.8	0.5	1.8	1.9	0.4	0.8	1.1	1.0	12.4
	Mean	1.2	1.8	1.0	1.7	1.9	2.4	2.4	2.4	1.3	1.3	1.7	1.2	20.3
Frankfort-on-Maine	1854	...	...	...	...	...	...	1.5	3.4	0.1	1.7	1.1	2.2	...
	1855	0.5	0.1	0.9	0.3	1.2	3.2	3.3	1.3	0.1	1.3	0.4	1.2	13.8
	1856	1.2	0.4	0.2	2.3	3.8	2.7	2.0	1.7	1.7	0.8	1.5	1.0	19.1
	1857	1.2	0.3	0.9	1.4	2.4	1.4	1.4	1.8	2.3	1.6	0.9	0.6	16.2
	Mean	1.0	0.3	0.6	1.3	2.5	2.4	2.2	1.6	1.4	1.2	0.9	0.9	16.4
Bonn.....	1849	1.5	1.5	1.1	2.3	1.7	0.9	2.2	2.0	0.8	4.0	1.0	3.5	22.5
	1850	2.5	2.4	0.8	2.4	1.2	1.1	2.9	4.9	1.9	1.2	1.5	1.2	24.0
	1851	1.2	0.5	3.2	2.4	2.9	3.3	3.5	1.8	4.0	2.1	2.7	0.6	28.2
	1852	1.6	2.6	1.6	1.0	3.6	4.3	2.2	5.2	1.7	2.4	2.3	2.0	30.5
	Mean	1.7	1.8	1.7	2.0	2.3	2.4	2.7	3.5	2.1	2.4	1.9	1.8	26.3

RAINFALL OF GERMANY.

DETAILS OF MONTHLY FALL.

Period.		Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Posen	1848	0.4	2.0	1.0	2.1	0.5	4.8	1.9	1.0	3.9	2.5	1.2	0.6	21.9
	1849	3.3	1.6	1.8	1.5	1.3	1.0	2.6	1.7	1.4	1.4	1.8	1.1	20.5
	1850	1.8	2.0	1.1	1.4	1.9	1.5	1.7	1.2	1.2	3.1	2.2	0.9	20.0
	1851	1.1	0.5	1.4	1.5	2.0	1.7	1.2	1.5	1.7	0.9	4.4	1.0	18.9
	1852	1.3	2.0	0.4	0.6	1.4	3.2	1.0	4.4	2.2	1.5	1.6	1.5	21.1
	1853	0.9	1.3	0.9	1.4	0.7	5.3	3.8	1.4	2.9	1.2	0.3	0.5	20.6
	1854	1.7	1.4	0.9	0.4	0.8	2.9	5.8	4.3	0.7	0.7	2.7	3.0	25.3
	1855	1.6	0.8	0.9	0.8	1.9	1.7	4.3	3.8	0.4	1.6	1.2	0.6	19.6
	1856	1.1	1.1	0.5	0.6	1.9	4.4	2.1	3.2	1.4	0.7	1.2	1.0	19.2
	1857	0.5	0.4	0.6	1.7	1.0	1.6	3.2	1.4	1.3	0.6	0.2	0.8	13.3
	Mean	1.4	1.3	0.9	1.2	1.3	2.8	2.8	2.4	1.7	1.4	1.7	1.1	20.0
Salzuflen.....	1848	0.1	3.3	1.6	2.1	0.3	3.2	1.0	4.8	2.4	1.6	2.4	0.6	23.4
	1849	2.1	1.4	1.0	1.7	1.4	2.5	2.3	1.4	1.2	2.2	1.4	2.7	21.3
	1850	1.4	2.6	0.9	2.2	2.7	0.8	1.5	3.9	0.2	2.0	1.9	2.5	22.6
	1851	0.9	0.7	3.0	1.7	2.8	2.2	2.1	3.3	3.8	1.1	3.1	0.5	25.2
	1852	2.6	3.9	0.8	0.6	2.0	3.2	1.6	1.2	2.9	3.1	2.4	2.4	26.7
	1853	2.8	1.9	0.9	2.0	2.3	3.3	2.0	1.2	2.7	2.6	0.3	0.7	22.7
	Mean	1.6	2.3	1.4	1.7	1.9	2.5	1.8	2.6	2.2	2.1	1.9	1.6	23.6
Cleve.....	1848	2.6	2.6	1.7	2.4	2.2	2.9	3.1	4.9	2.4	2.1	3.0	1.6	31.5
	1849	3.1	2.6	1.3	2.2	3.0	2.0	3.6	1.3	1.6	5.9	1.6	4.5	32.7
	1850	2.4	4.3	1.3	2.7	2.5	1.2	3.2	5.7	1.4	3.0	2.3	3.3	33.3
	1851	1.9	1.2	4.8	3.9	3.4	1.7	2.7	2.7	1.2	1.7	4.4	0.7	30.3
	1852	3.4	5.4	1.2	0.4	3.1	3.9	0.5	3.0	3.0	4.9	3.0	3.4	35.2
	1853	3.3	2.2	1.0	4.1	2.4	3.5	3.0	2.7	3.3	2.4	0.1	1.3	29.3
	1854	2.9	3.2	0.4	1.9	2.0	5.0	2.3	3.3	1.4	2.2	2.8	6.4	33.8
	1855	1.2	1.4	1.9	1.1	2.8	3.0	5.5	2.4	0.5	4.6	0.9	1.7	27.0
	1856	2.7	2.5	0.4	1.9	4.2	3.0	2.6	4.4	2.9	0.5	3.3	2.6	31.0
	1857	2.8	0.6	1.6	1.6	2.0	1.0	3.1	1.4	1.9	1.5	1.1	1.0	19.6
	Mean	2.6	2.6	1.6	2.2	2.8	2.7	3.0	3.2	2.0	2.9	2.2	2.6	30.4
Paderborn ...	1848	0.2	3.4	1.8	2.9	1.0	3.5	1.8	6.1	2.0	2.7	3.0	0.3	28.7
	1849	3.4	3.0	1.8	2.1	2.0	2.5	3.3	2.2	2.0	3.0	1.1	2.7	29.1
	1850	1.5	4.7	1.7	2.0	2.3	1.5	3.0	5.9	0.7	2.5	3.3	1.3	30.4
	1851	0.8	1.1	3.9	2.3	3.1	3.2	2.4	2.4	4.1	1.6	2.5	1.0	28.4
	1852	3.0	5.1	1.0	0.6	3.4	3.1	5.6	3.2	2.2	3.2	2.7	2.4	35.5
	1853	2.9	3.1	0.9	1.8	2.7	4.3	3.2	2.9	3.1	2.5	0.6	0.7	28.7
	1854	1.0	2.0	0.8	1.5	4.0	4.8	2.6	3.2	1.0	1.9	3.1	7.2	33.1
	1855	1.3	1.1	2.2	1.9	2.9	3.8	...	...	...	...	...	...	...
	1856	1.6	2.2	0.1	2.2	3.5	2.4	3.0	3.0	2.1	0.5	4.2	2.2	27.0
	1857	1.6	0.2	1.0	0.5	1.9	1.1	1.1	0.1	0.0	0.4	1.2	1.6	10.7
	Mean	1.7	2.6	1.5	1.8	2.7	3.0	2.9	3.2	1.9	2.0	2.4	2.2	28.0
Gütersloh ...	1848	0.5	3.8	1.7	2.8	0.6	3.7	1.7	5.5	2.0	2.1	2.9	0.8	28.1
	1849	3.1	2.1	1.4	1.8	2.2	0.8	3.6	1.9	1.6	3.1	1.4	3.3	26.3
	1850	2.1	4.1	1.0	2.7	2.3	0.9	0.9	3.7	3.1	2.2	3.0	3.0	29.0
	1851	1.2	1.0	4.1	2.1	3.3	3.5	4.6	2.8	2.6	1.3	2.8	0.7	30.0
	1852	2.7	5.2	1.3	0.7	2.4	2.7	3.8	1.8	3.0	4.0	2.5	2.4	32.5
	1853	3.5	1.1	1.1	3.3	2.3	3.5	3.6	1.8	2.6	2.5	0.3	0.8	26.4
	1854	1.8	2.4	1.1	1.0	3.3	5.7	1.6	3.0	1.2	3.5	2.5	6.7	33.8
	1855	1.4	1.1	1.9	1.7	2.8	3.2	7.4	2.0	0.6	3.4	1.0	1.3	27.8
	1856	1.8	2.1	0.4	2.2	4.1	2.1	2.2	4.2	2.6	0.8	3.7	1.7	27.9
	1857	1.6	1.5	1.9	2.4	2.0	1.2	3.4	2.2	1.1	0.6	1.1	1.4	20.4
	Mean	2.0	2.4	1.6	2.1	2.5	2.7	3.3	2.9	2.0	2.4	2.1	2.2	28.2
Lingen	1855	0.9	1.2	1.7	1.3	2.3	3.8	4.4	2.3	0.4	3.3	1.1	1.5	24.2
	1856	2.1	1.5	0.3	1.2	4.4	1.4	4.8	4.8	2.0	0.7	3.9	1.8	28.9
	1857	2.5	0.1	2.3	1.6	0.9	1.0	4.2	1.1	1.3	1.4	1.4	0.8	18.6
	Mean	1.9	0.9	1.4	1.4	2.5	2.1	4.5	2.7	1.2	1.8	2.1	1.4	23.9

RAINFALL OF GERMANY.

DETAILS OF MONTHLY FALL.

Period.		Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Brocken	1848	0.0	6.7	2.7	2.4	1.2	3.9	4.0	4.1	10.4	8.9	7.2	1.0	52.5
	1849	4.9	4.0	5.2	3.8	2.9	2.5	6.2	7.9	5.9	6.3	0.9	6.8	57.3
	1850	3.9	6.7	4.5	3.9	4.9	3.4	5.9	...	4.1	...	...	...	...
	1854	0.1	4.3	2.2	0.3	2.0	5.5	5.8	6.9	3.6	4.5	4.3	5.1	44.6
	1855	4.1	1.1	1.5	1.1	3.7	5.2	17.3	5.1	2.3	5.5	1.7	1.4	50.0
	1856	2.7	2.8	0.3	2.5	2.7	4.1	5.3	9.2	5.1	2.3	5.3	3.3	45.6
	1857	1.7	4.3	1.8	2.3	1.6	4.1	2.9	3.7	0.7	1.3	1.0	4.2	29.6
	Mean	2.5	4.3	2.6	2.3	2.7	4.1	6.8	6.1	5.4	4.8	3.4	3.6	46.6
Torgau	1848	0.2	2.3	1.0	2.0	1.1	2.1	1.3	2.7	2.6	3.4	2.7	0.2	21.6
	1849	2.3	1.5	1.6	2.9	1.1	1.5	2.6	1.4	1.4	1.9	0.8	1.9	20.9
	1850	1.2	3.3	0.8	1.0	2.5	3.4	1.9	2.1	1.0	3.0	2.8	2.3	25.3
	1851	0.6	0.7	2.3	4.1	3.1	2.5	2.5	1.3	4.9	1.5	2.6	0.4	26.5
	1852	2.2	3.2	1.2	0.6	4.0	3.5	2.4	1.9	1.6	1.1	2.4	1.2	25.3
	1853	1.8	1.2	1.4	3.1	0.5	6.2	2.9	2.5	2.0	1.3	0.9	0.3	24.1
	1854	1.1	1.9	0.6	1.2	1.9	4.3	3.9	5.1	0.6	1.2	1.8	5.2	28.8
	1855	0.7	2.4	1.1	1.6	2.3	2.7	4.2	1.2	0.6	1.5	1.4	0.8	20.5
	1856	0.9	1.9	0.5	0.7	2.2	3.6	0.9	3.2	1.6	0.6	2.5	1.3	19.9
	1857	0.8	0.5	1.0	2.2	0.7	0.3	3.5	0.5	1.2	0.7	0.8	0.5	12.7
	Mean	1.2	1.9	1.2	1.9	1.9	3.0	2.6	2.2	1.8	1.6	1.9	1.4	22.6
Heiligenstadt	1848	0.2	3.2	1.8	3.4	0.6	2.2	2.4	5.6	2.5	3.4	3.6	0.6	29.5
	1849	2.7	1.6	1.7	2.8	1.8	1.4	4.3	2.4	2.2	3.2	0.6	0.9	25.6
	1850	1.4	3.2	1.3	3.3	3.2	1.5	5.3	3.5	2.2	1.6	2.0	2.8	31.3
	1851	0.8	0.6	4.0	3.2	3.4	4.1	2.1	1.9	5.6	0.6	0.5	0.2	27.0
	1852	2.6	1.7	1.6	2.6	2.6	1.9	0.9	1.9	3.5	2.2	2.4	2.3	26.2
	1853	2.2	1.3	1.2	3.9	1.8	6.4	2.6	1.9	2.4	1.7	0.8	0.4	26.6
	1854	0.8	2.3	0.5	0.9	1.9	2.8	3.4	4.7	1.0	1.6	2.6	5.4	27.9
	1855	0.9	1.2	1.7	1.7	1.8	3.0	5.3	2.3	0.5	2.5	1.5	0.9	23.3
	1856	0.8	1.5	0.3	2.9	4.1	3.1	1.6	4.2	1.2	0.8	2.0	0.8	23.3
	1857	0.6	0.1	1.9	1.7	1.0	0.6	1.3	1.3	1.4	0.8	1.0	0.6	12.3
	Mean	1.3	1.7	1.6	2.6	2.2	2.7	2.9	3.0	2.3	1.8	1.7	1.5	25.3
Ballenstädt	1851	2.1	2.8	2.0	6.5	3.8	2.4	5.9	2.5	1.5	2.0	6.1	0.2	37.8
	1852	2.6	3.8	1.3	0.4	6.1	6.1	2.1	2.5	5.1	2.8	3.9	3.3	40.0
	1853	3.7	2.5	5.2	3.7	3.4	14.0	3.5	3.5	4.1	4.3	1.7	1.1	50.7
	1854	0.7	1.5	2.4	2.7	2.7	7.3	5.4	3.0	1.3	4.3	3.5	8.6	43.4
	1855	3.5	3.2	1.2	2.7	2.5	5.3	8.1	2.9	3.0	1.6	1.1	0 8	35.9
	1856	1.2	3.6	0.6	3.3	4.8	2.5	1.0	3.4	1.1	1.2	2.0	1.0	25.7
	1857	1.7	0.2	1.4	3.4	0.4	1.4	1.2	1.0	3.7	2.8	3.1	2.5	22.8
	Mean	2.2	2.5	2.0	3.2	3.4	5.6	3.9	2.7	2.8	2.7	3.1	2.5	36.6
Görlitz	1848	0.5	2.0	1.2	3.5	1.8	3.6	2.1	2.0	2.8	2.2	2.0	0.5	24.2
	1849	3.2	2.2	2.7	2.6	2.0	2.6	2.8	2.6	1.1	2.4	1.3	2.2	27.7
	1850	1.7	1.4	0.7	1.0	1.9	4.2	1.8	3.2	1.1	4.4	2.6	1.2	25.2
	1851	1.0	0.5	2.5	3.2	2.6	1.8	3.3	2.2	5.0	1.9	4.6	1.6	30.2
	1852	1.4	4.1	0.9	0.7	4.0	3.6	2.1	7.1	5.7	1.1	2.4	1.0	34.1
	1853	1.4	1.7	1.4	3.0	1.6	4.2	2.2	4.1	3.5	1.8	0.6	0.4	25.9
	1854	1.3	2.7	1.3	1.0	2.9	4.7	3.4	4.4	0.8	0.9	2.7	4.5	30.6
	1855	1.8	1.7	1.5	1.4	3.8	2.6	4.9	3.4	1.1	0.9	1.3	0.8	25.2
	1856	1.1	1.5	0.5	0.8	2.8	5.8	1.5	4.0	0.9	0.2	2.8	1.2	23.1
	1857	0.8	0.6	1.0	2.0	0.5	0.5	3.9	1.3	2.0	0.4	0.6	1.1	14.7
	Mean	1.4	1.8	1.4	1.9	2 4	3.4	2.8	3.4	2.4	1.6	2.1	1.5	26.1
Aachen	1848	0.2	2.9	2.3	4.6	1.3	2.1	1.6	5.6	1.3	3.2	2.0	1.0	28.1
	1849	2.8	1.7	1.3	1.3	0.4	0.6	3.1	0.7	1.2	3.5	0.8	4.7	22.1
	1850	3.4	1.6	0.9	1.5	1.5	0.8	2.2	4.4	0.8	0.3	2.7	3.0	23.1
	1851	2.0	2.0	6.6	3.6	4.5	1.0	3.7	4.8	6.1	1.4	3.8	0.7	40.2
	Mean	2.1	2.0	2.8	2.8	1.9	1.1	2.6	3.9	2.4	2.1	2.3	2.4	28.4

RAINFALL OF GERMANY.

DETAILS OF MONTHLY FALL.

Period.		Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Zechen (Near Guhran.)	1848	0.9	2.2	1.5	2.0	0.9	3.0	1.9	1.1	1.6	2.3	1.5	0.2	19.1
	1849	1.8	2.0	3.2	1.7	1.2	2.1	1.5	1.9	1.0	2.7	2.5	3.0	24.6
	1850	2.1	2.9	1.6	1.5	2.1	5.9	2.2	1.4	1.3	4.3	3.3	1.4	30.0
	1851	0.5	0.9	2.2	1.7	1.9	2.1	3.2	3.1	2.9	2.3	4.3	1.1	26.2
	1852	1.6	1.7	0.8	0.3	2.7	2.9	1.3	3.6	1.4	0.9	1.4	1.1	19.7
	1853	0.9	2.1	2.4	1.5	2.0	3.2	1.7	1.3	1.5	1.5	0.4	0.8	19.3
	1854	1.5	1.4	0.9	1.6	2.0	4.5	4.5	10.0	0.8	1.3	2.5	2.6	33.6
	1855	1.9	1.4	1.4	1.4	2.2	3.4	6.0	3.9	1.1	1.7	0.9	1.1	26.4
	1856	1.1	2.5	0.9	1.1	2.8	3.2	2.0	3.7	1.0	0.2	1.2	1.6	21.3
	1857	0.5	0.4	0.7	3.0	0.3	1.0	1.3	1.3	1.0	0.8	0.5	1.5	12.3
	Mean	1.3	1.8	1.6	1.6	1.8	3.1	2.6	3.1	1.4	1.8	1.8	1.4	23.3
Mühlhausen	1851	0.4	0.2	2.5	2.4	1.6	2.6	1.4	0.8	3.0	0.6	0.8	0.2	16.5
	1852	1.5	4.1	0.9	0.7	4.0	2.9	0.3	0.9	1.9	1.1	2.1	1.6	22.0
	1853	1.1	1.4	0.8	1.5	1.2	5.6	2.1	2.0	1.2	1.0	0.2	0.7	18.8
	1854	0.3	0.8	1.1	0.6	1.1	2.7	1.6	1.9	0.1	3.1	0.4	3.8	17.5
	1855	0.7	1.4	1.5	1.2	1.3	2.4	5.4	1.9	0.2	1.8	0.5	1.1	19.4
	1856	0.8	0.5	0.0	2.4	3.2	2.6	1.0	1.5	1.2	0.4	1.4	0.9	15.9
	1857	1.0	0.0	1.1	1.4	2.1	0.4	1.3	1.3	0.5	0.6	0.8	0.2	10.7
	Mean	0.8	1.2	1.1	1.5	2.1	2.7	1.9	1.5	1.2	1.2	0.9	1.2	17.3
Crefeld	1848	0.1	3.7	2.4	3.2	1.2	2.3	2.1	5.9	1.8	2.3	2.3	0.7	28.0
	1849	1.9	2.1	1.2	2.6	1.4	0.5	2.9	1.7	0.9	4.3	1.1	5.2	25.8
	1850	1.9	3.4	1.3	2.1	1.0	0.5	2.5	4.7	1.2	1.1	2.0	2.7	24.4
	1851	2.3	0.8	2.3	3.8	2.8	1.9	3.9	2.0	2.3	1.9	4.0	0.4	28.4
	1852	3.1	3.9	1.4	1.1	4.0	4.3	2.0	2.5	2.5	5.3	2.3	2.4	34.8
	1853	3.2	2.1	1.0	4.5	1.7	3.5	2.4	1.9	3.6	2.7	0.0	0.9	27.5
	1854	1.6	2.5	0.2	2.5	2.7	4.3	2.2	3.7	1.1	2.8	3.0	6.2	33.4
	1855	1.9	2.5	1.4	2.7	2.1	2.6	2.7	3.1	1.7	3.1	2.0	2.5	28.3
	1856	1.8	1.6	0.4	2.3	3.0	2.5	1.7	3.6	2.3	0.9	3.4	1.4	24.9
	1857	1.8	0.2	1.3	1.2	2.8	1.2	1.4	0.5	1.4	0.8	0.6	1.0	14.0
	Mean	1.9	2.3	1.3	2.6	2.3	2.4	2.4	2.9	1.9	2.4	2.1	2.4	26.9
Erfurt	1848	0.3	1.5	3.2	2.9	0.6	2.5	1.2	4.3	1.4	3.9	2.8	0.3	24.9
	1849	1.4	1.4	1.2	3.6	1.9	1.0	1.9	1.6	1.5	3.1	0.9	0.9	20.4
	1850	1.1	1.1	0.6	2.0	2.8	2.1	4.5	2.9	0.9	2.1	1.0	1.1	22.2
	1851	0.1	0.5	1.5	5.6	2.6	2.2	3.9	1.7	3.5	1.5	0.8	0.3	24.2
	1852	0.8	2.0	0.6	0.9	4.8	2.7	1.0	1.7	1.8	1.0	2.0	1.5	20.8
	1853	0.9	1.6	1.8	1.9	2.2	3.7	1.8	1.1	2.5	1.8	0.8	0.2	20.3
	1854	0.6	1.0	0.3	0.8	1.1	4.6	3.4	2.9	0.1	3.3	1.0	2.3	21.4
	1855	0.8	2.0	0.9	1.0	2.2	3.1	4.6	1.6	0.9	2.0	0.6	0.6	20.3
	1856	0.5	0.7	0.2	2.9	2.1	3.3	1.3	2.0	2.2	0.2	1.2	0.5	17.1
	1857	0.7	0.2	1.3	2.5	2.2	1.1	2.2	2.9	1.3	0.9	0.7	0.2	16.2
	Mean	0.7	1.2	1.2	2.4	2.2	2.6	2.6	2.3	1.6	2.0	1.2	0.8	20.8
Gotha	1848	0.9	1.9	0.8	3.4	0.1	2.1	2.7	5.6	1.6	5.0	3.7	0.4	28.2
	1849	1.9	1.4	2.1	2.0	2.4	2.1	4.0	2.8	2.5	4.1	0.8	2.1	28.2
	1850	0.9	1.8	0.9	2.4	3.9	2.6	3.8	4.3	0.9	2.7	1.1	1.8	27.1
	1851	0.3	0.4	2.2	4.3	2.8	2.8	4.0	2.6	5.0	1.6	1.0	0.5	27.5
	1852	1.3	3.4	0.8	1.1	3.6	3.6	1.0	3.5	2.2	2.0	1.8	1.8	26.1
	1854	0.7	1.8	0.5	1.1	1.3	3.4	3.6	3.7	0.5	3.1	2.0	2.7	24.4
	1855	1.3	1.7	1.4	1.1	2.3	3.5	6.1	2.0	0.8	2.8	0.6	0.8	24.4
	Mean	1.1	1.8	1.3	2.2	2.3	2.9	3.6	3.5	1.9	3.0	1.6	1.4	26.6
Ziegenrück	1851	0.3	0.5	1.5	4.3	3.3	3.3	5.5	3.2	4.4	1.5	2.4	0.5	30.7
	1852	0.8	2.5	0.5	0.5	5.0	3.2	1.1	5.1	2.4	1.0	2.5	1.2	25.8
	1853	1.5	1.1	1.1	2.6	2.8	3.9	2.4	2.9	3.4	0.8	2.4	0.7	25.6
	1854	0.7	2.2	1.2	2.2	1.3	5.2	3.7	4.4	0.7	3.1	2.7	2.2	29.6
	1855	1.5	2.7	1.0	1.7	2.1	3.0	6.1	3.6	0.6	2.4	1.0	0.2	26.5
	1856	0.8	1.5	0.9	1.2	3.1	5.2	0.4	0.4	0.3	0.3	0.2	0.2	14.5
	Mean	0.9	1.7	1.0	2.1	2.9	4.0	3.2	3.3	2.0	1.5	1.9	0.9	25.4

RAINFALL OF GERMANY.

DETAILS OF MONTHLY FALL.

Period.		Jan.	Feb.	Mar.	April	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Arnstadt.....	1848	0.	1.8	1.1	2.	0.5	1.2	1.8	3.6	1.1	3.7	3.8	0.	21.7
	1849	0.9	1.1	1.5	3.9	1.8	1.5	1.	1.	1.2	2.	0.6	1.0	19.2
	1850	1.1	1.	0.6	1.8	2.2	2.6	3.0	4.	0.9	2.	0.9	1.0	23.1
	1851	0.3	0.8	1.6	4.	2.	2.8	4.	2.	4.7	1.6	0.9	0.8	24.6
	1852	0.8	2.0	0.	0.7	3.0	2.0	1.3	4.	0.7	1.8	1.8	1.4	20.3
	1853	1.8	1.9	1.4	1.3	2.	4.9	1.9	1.2	3.3	1.1	1.2	0.4	21.3
	Mean	0.8	1.4	1.2	2.	1.0	2.5	2.3	2.8	2.	2.1	1.5	0.8	21.7
26 Years' Mean		1.9	0.9	1.3	1.	2.	2.6	2.5	2.3	1.7	1.3	1.4	1.7	21.0
Cologne	1848	0.	2.5	1.	6.6	0.9	2.7	2.	4.3	1.8	2.7	2.2	0.2	29.4
	1849	2.3	2.0	1.	1.3	1.0	0.2	2.7	1.8	0.1	3.8	1.0	4.2	23.7
	1850	1.2	2.8	1.3	2.5	2.5	0.9	2.8	5.	1.6	1.3	1.	1.3	24.6
	1851	1.9	0.7	3.2	2.	6.3	2.8	3.	1.0	3.1	1.	2.7	0.	30.1
	1852	2.5	3.1	1.2	0.	3.4	3.1	1.4	2.3	3.	1.2	2.8	2.4	28.0
	1853	2.7	0.7	0.2	3.	0.	5.7	2.	3.0	2.9	2.3	0.	1.	24.8
	1854	1.3	1.0	0.6	1.	3.	4.3	1.4	3.1	0.	2.	3.	4.	28.3
	1855	2.4	0.5	0.1	0.	3.1	3.9	4.2	1.7	0.1	4.	0.7	0.3	22.0
	1856	0.	0.2	0.1	2.	2.	2.2	0.8	2.2	1.	0.5	2.5	1.6	15.9
	1857	1.1	0.1	1.1	0.8	2.	0.6	1.5	1.5	1.8	1.6	0.	1.1	13.1
	Mean	1.6	1.5	1.3	2.2	2.7	2.6	2.3	2.	1.7	2.2	1.7	1.7	24.0
Neisse	1848	0.7	1.5	1.6	2.6	2.5	4.8	5.4	1.1	2.	1.3	3.	0.	27.2
	1849	1.6	0.6	1.5	0.8	1.4	2.7	2.3	3.	0.0	2.9	2.3	1.8	21.8
	1850	1.3	0.6	1.2	1.1	0.7	1.3	2.2	1.2	1.	1.	0.8	0.	14.1
	Mean	1.2	0.9	1.4	1.3	1.5	2.9	3.3	1.	1.	2.1	2.2	0.	21.0
Halle	1851	0.4	0.8	1.3	2.9	2.	2.4	3.5	0.7	4.	1.3	0.	0.5	20.7
	1852	1.3	2.8	0.6	0.8	3.1	1.8	0.2	1.1	1.	0.3	2.5	1.9	17.5
	1853	1.2	1.3	1.8	2.	2.7	6.4	1.8	2.	1.	1.9	1.4	0.8	24.3
	1854	0.3	1.3	1.0	0.8	1.9	5.7	3.2	2.	0.	2.2	0.4	2.9	22.3
	1855	1.2	1.5	0.8	1.0	2.7	2.2	6.	1.0	0.	1.3	0.2	0.5	19.6
	1856	0.7	1.6	0.3	0.8	4.1	5.3	0.6	2.0	1.8	0.	1.9	1.	21.1
	1857	0.8	0.1	0.7	2.5	1.1	0.3	1.4	3.2	0.4	1.4	0.4	0.5	12.4
	Mean	0.8	1.3	0.9	1.5	2.5	3.4	2.5	1.	1.	1.2	1.2	0.	19.7
Ratibor	1848	1.4	1.7	1.9	4.3	3.0	1.8	2.8	2.7	1.7	4.9	3.2	0.2	22.6
	1849	0.2	1.0	1.7	1.8	2.7	2.2	2.5	6.	0.	2.5	1.2	1.	24.1
	1850	1.7	1.4	1.1	1.5	1.9	2.7	3.2	1.1	2.7	3.3	1.8	1.1	23.5
	1851	0.6	0.5	1.1	1.1	3.8	2.5	3.0	5.3	3.7	1.4	3.8	1.	28.7
	1852	0.9	1.5	0.5	0.6	2.3	3.0	2.1	3.8	1.	1.9	1.9	0.	20.7
	1853	0.7	1.3	2.3	2.1	2.5	5.5	6.0	2.3	2.6	0.8	0.3	1.3	27.3
	1854	1.9	2.2	1.7	0.8	2.4	3.9	2.9	8.6	1.1	1.2	1.8	2.1	30.6
	1855	2.3	2.0	2.3	0.8	1.8	3.8	2.8	4.8	1.4	1.9	1.3	1.2	26.4
	1856	0.3	1.5	0.2	0.7	1.6	3.4	2.5	1.5	2.9	0.	1.9	1.	18.3
	1857	0.5	0.3	0.9	1.5	2.0	2.1	1.3	1.3	1.5	1.6	1.5	1.	14.9
	Mean	1.1	1.3	1.4	1.2	2.4	3.1	2.9	3.7	2.	1.5	1.9	1.6	23.7
Boppard	1848	0.2	3.7	3.8	5.2	0.6	2.7	2.2	4.	2.	3.	2.6	1.2	32.4
	1849	1.5	1.1	0.9	2.0	3.5	1.9	3.6	1.7	1.	2.	1.3	2.2	23.1
	1850	2.3	2.3	1.0	2.5	1.2	0.9	2.7	5.9	1.	1.5	2.1	2.3	26.3
	1851	0.9	0.8	3.2	3.6	3.2	1.5	3.1	3.3	2.	0.	2.1	0.	25.6
	1852	2.4	2.4	1.7	0.7	3.4	2.8	1.6	3.2	2.7	3.	2.7	2.3	28.9
	1853	3.2	1.2	0.4	4.	2.7	3.4	3.0	2.2	2.	1.6	0.9	0.9	23.8
	1854	2.5	2.1	0.6	1.7	3.4	4.2	2.1	3.6	1.0	2.1	3.2	4.7	31.2
	1855	0.9	1.7	2.0	1.8	2.1	4.5	4.1	2.8	0.5	5.1	1.4	1.7	28.6
	1856	1.0	0.5	0.6	2.5	4.0	4.5	1.4	1.2	2.9	0.6	2.8	1.1	23.1
	1857	1.4	0.2	1.3	2.0	3.5	2.0	1.6	1.0	2.3	0.	1.5	0.8	18.2
	Mean	1.6	1.6	1.6	2.6	2.8	2.8	2.5	2.9	1.9	2.1	2.	1.7	26.1

RAINFALL OF GERMANY.

DETAILS OF MONTHLY FALL.

Period.		Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Neunkirchen	1851	2.4	0.5	4.0	2.5	2.6	1.5	3.8	1.7	2.7	1.6	1.0	0.2	24.5
	1852	2.9	1.6	1.1	0.3	3.2	5.2	1.8	5.7	2.2	3.2	4.2	1.8	33.2
	1853	4.7	0.4	0.5	3.1	3.4	2.4	2.1	1.5	1.7	2.6	0.2	0.5	23.1
	1854	1.6	0.7	0.1	1.0	3.8	3.9	2.6	2.1	0.1	3.8	2.3	2.0	24.0
	1855	0.4	1.5	2.4	1.2	2.3	3.5	4.4	2.6	0.4	3.0	1.5	1.1	24.3
	1856	2.9	0.4	0.4	4.2	5.5	4.8	2.7	2.5	3.4	1.2	2.4	1.7	32.1
	1857	2.0	0.5	1.0	1.5	2.3	1.1	1.4	1.4	1.7	1.0	0.5	0.7	15.1
	Mean	2.4	0.8	1.4	2.0	3.3	3.2	2.7	2.5	1.8	2.3	1.7	1.1	25.2
Kreuznach	1851	0.2	0.4	2.5	2.2	2.6	1.4	3.1	2.8	1.7	0.7	1.1	0.3	19.0
	1852	1.9	1.8	1.0	0.2	2.9	2.6	1.2	4.0	1.8	1.9	3.5	1.3	24.1
	1853	2.7	1.2	0.4	2.5	1.0	3.0	1.8	1.2	1.3	1.6	0.4	0.6	17.7
	1854	2.4	1.0	0.1	0.8	3.2	3.4	2.4	3.4	0.3	2.4	2.1	2.0	23.5
	1855	0.7	1.1	1.7	0.9	1.2	3.8	4.3	1.0	0.2	1.8	0.9	1.5	19.1
	1856	1.4	0.3	0.4	2.4	3.6	3.2	2.0	1.6	3.7	0.5	2.1	0.9	22.1
	1857	0.5	0.2	0.4	0.6	2.0	0.6	0.3	0.7	3.2	0.9	1.1	0.3	10.8
	Mean	1.4	0.9	0.9	1.4	2.4	2.6	2.1	2.1	1.7	1.4	1.6	1.0	19.5
Trier	1849	2.3	1.8	1.0	3.1	1.9	1.8	5.5	2.1	1.7	2.5	1.6	2.2	27.5
	1850	2.2	2.1	0.9	3.2	2.8	0.9	3.0	4.9	1.1	2.5	2.4	0.9	26.5
	1851	1.0	0.7	3.8	3.6	2.3	1.8	2.9	1.8	2.4	1.6	1.3	0.5	23.7
	1852	3.3	2.0	0.7	1.0	3.7	4.9	2.5	3.5	2.1	2.0	3.5	3.0	32.2
	1853	4.1	1.3	0.6	4.0	3.1	2.5	2.6	2.4	1.6	3.6	0.1	0.7	26.6
	1854	2.9	1.7	0.3	1.5	3.2	5.5	2.8	6.5	0.4	3.3	1.9	3.4	33.4
	1855	0.8	2.0	2.3	1.2	3.1	3.4	4.1	3.3	0.5	3.4	1.3	2.0	27.4
	1856	2.3	0.4	0.6	5.1	4.2	6.0	2.8	1.3	1.4	1.0	2.8	1.8	29.7
	1857	2.0	0.4	0.9	2.4	3.1	0.9	1.4	1.5	1.1	1.4	1.2	0.9	17.2
	Mean	2.3	1.4	1.2	2.8	3.1	3.1	3.1	3.0	1.4	2.4	1.6	1.7	27.1

RAINFALL OF DENMARK.

Stadil	1846	2.8	3.6	2.9	1.7	0.8	3.9	1.4	1.4	5.9	2.4	3.0	1.7	31.5
	1847	2.5	0.3	2.9	3.4	3.1	1.1	3.0	7.3	3.0	3.4	3.7	0.0	33.7
	1848	3.5	3.0	1.9	0.2	2.9	4.8	7.8	1.9	4.4	6.3	3.2	2.8	42.7
	1849	4.6	0.6	2.3	1.2	1.0	2.8	2.5	1.3	2.5	1.7	1.5	0.9	22.9
	1850	3.8	0.8	2.0	2.2	2.9	1.7	6.2	3.1	3.2	7.3	3.5	2.2	38.9
	1851	1.0	3.9	3.8	1.6	3.1	3.0	2.1	1.3	4.4	3.8	1.5	1.5	31.0
	Mean	3.0	2.0	2.6	1.7	2.3	3.0	3.8	2.7	3.9	4.2	2.7	1.5	33.4
Traneberg	1846	2.0	1.6	2.1	1.2	0.9	2.0	2.9	0.9	1.2	3.7	1.0	2.1	21.6
	1847	2.0	2.2	1.6	2.5	2.1	3.0	0.6	1.9	2.3	1.5	1.5	0.7	21.9
	1848	0.2	3.0	2.7	1.3	0.6	3.8	3.7	4.3	1.6	4.4	1.8	1.0	28.4
	1849	1.5	1.0	1.8	0.4	1.2	1.2	3.3	1.0	1.3	3.8	1.0	1.6	19.0
	1850	0.9	2.1	0.8	1.9	0.8	1.6	2.0	2.5	2.2	3.0	3.1	0.8	21.8
	1851	2.1	1.0	3.4	3.2	1.4	2.3	0.7	1.5	1.1	3.1	3.1	0.4	23.3
	Mean	1.4	1.8	2.1	1.8	1.2	2.3	2.2	2.0	1.6	3.3	1.9	1.1	22.7
No. of Days		10	9	9	8	8	10	12	11	10	11	10	8	116
Vederso	1846	2.7	2.3	3.7	1.8	2.2	0.5	4.1	0.8	1.5	4.6	1.9	6.0	32.1
	1847	1.4	2.2	0.9	1.4	2.6	2.5	0.8	2.3	4.9	3.1	2.4	1.9	26.4
	1848	0.4	3.3	3.5	2.1	0.4	2.7	4.3	6.8	1.9	4.6	4.8	2.4	37.2
	1849	1.7	2.5	2.6	1.5	1.1	1.0	3.4	3.1	2.1	2.3	1.9	1.9	25.1
	1850	0.7	3.8	1.5	2.0	1.6	1.5	1.2	3.6	1.2	3.6	4.9	1.3	26.9
	1851	2.3	1.2	3.2	3.5	1.5	2.1	1.9	2.1	0.8	3.7	2.2	2.2	26.7
	Mean	1.5	2.5	2.6	2.1	1.6	1.7	2.6	3.1	2.1	3.6	3.0	2.6	29.0
No. of Days		14	18	20	17	14	13	18	17	14	20	19	18	202

RAINFALL AT GENEVA, GREAT ST. BERNARD, TURIN, FLORENCE, AND NAPLES.

DETAILS FROM 1847 TO 1858.

Period.		Jan	Feb	Mar	Apr	May	Jne.	Jly.	Aug	Sep	Oct.	Nov	Dec	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Geneva.....	1847	1.9	1.4	1.5	3.5	1.4	3.7	2.5	4.2	1.5	2.9	0.6	2.1	27.2
Height 1253 feet.	1848	0.9	1.4	3.4	6.0	0.7	6.4	2.7	3.4	2.1	3.4	1.6	1 2	33.2
Lat. 46° 12′ N.	1849	3.3	0.6	1.1	2.4	3.1	5.0	1.9	0.9	3.6	7.7	1.7	9.0	40.3
Long. 6° 8′ E.	1850	1.6	0.9	1.8	5.0	4.4	2.6	1.4	3.3	3.1	2.3	2.9	9.1	38.4
Mean Temp.	1851	2.0	1.0	2.8	2.2	1.9	0.1	5.3	3.7	3.3	3.9	1.2	0.2	27.6
49.5° Fah.	1852	1.8	0.7	0.2	0.3	2.2	3.8	2.3	8.4	3.3	6.5	3.9	1.5	34 9
	1853	2.3	0.8	0.6	7.0	6.0	2.7	3.3	2.5	4.5	5.1	1.4	0.5	36.7
	1854	0.8	0.2	0.0	0.8	2.4	4.9	4.0	2.8	0.0	4.2	3.0	2.0	25.1
	1855	1.3	5.1	1.7	0.8	3.8	2.7	2.9	2.2	4.3	10.9	2.4	1.2	39.3
	1856	4.9	1.1	2.4	3.5	11.7	2.8	2.7	2.3	4.6	0.8	1.2	2.5	40.5
	1857	1.2	0.7	1.0	1.6	2.1	2.0	0.7	3.5	2.4	3.2	1.6	0.7	20.7
	1858	0.1	0.7	1.0	2.4	3.2	0.6	5.5	3.5	2.8	2.8	3.1	2.4	28.1
	Mean	1.8	1.2	1.5	2.9	3.6	3.1	2.9	3.4	2.9	4.5	2.1	2.7	32.6
No. of Days Rain fell ...		9.9	8.1	9.3	9.4	11.4	9.5	8.9	9.8	11.6	10.3	10.8	9.0	118.0
Great St. Bernard...	1847	3.2	5.0	1.6	9.0	0.5	4.5	3.7	3.3	1.9	1.5	4.2	3.2	41.6
Height 8200 feet.	1848	3.4	10.9	8.3	10.9	0.2	8.8	3.6	1.9	2.7	5.6	4.0	3.5	63.8
Lat. 45° 50′ N.	1849	8.6	2.4	4.0	8.5	6.8	7.8	3.1	1.6	2.8	1.2	5.7	4.5	57.0
Long. 7° 15′ E.	1850	5.7	5.2	1.5	5.2	4.8	2.6	1.4	4.2	1.3	4.2	5.5	1.9	43.5
Mean Temp.	1851	3.8	3.3	5.8	8.7	6.3	0.9	7.8	3.9	5.7	3.3	3.1	0.1	52.7
30.25° Fah.	1852	4.2	4.9	1.8	3.2	4.4	4.8	2.1	4.6	4.3	5.1	1.8	6.0	47.2
	1853	6.2	5.7	6.7	2.4	6.4	3.2	1.8	3.2	2.7	6.7	2.9	2.4	50.3
	1854	3.8	0.9	0.2	2.0	5.3	6.7	5.1	4.7	0.0	4.1	4.5	2.3	39.6
	1855	2.5	3.5	3.1	3.3	4.6	4.9	2.2	1.8	2.4	12.5	3 4	1.4	45.6
	1856	5.5	1.6	0.6	5.5	7.3	3.3	2.5	2.2	3.5	3.3	0.9	3.5	39.7
	Mean	4.7	4.3	3.4	5.9	4.7	4.7	3.3	3.1	2.7	4.8	3.6	2.9	48.1
Dalton's Mean 32 years..		5.9	6.8	7.0	5.6	2.7	3.2	4.1	4.3	4.8	5.4	4.5	5.4	59.7
No. of Days		14.4	9.9	12.5	11.2	12.0	7.9	7.7	8.0	10.1	12.7	12.5	10.0	128.9
Turin	1849	0.0	0.0	1.7	6.9	2.9	1.1	1.0	2.7	4.2	3.1	2.6	4.0	30.2
Height 857 feet.	1850	0.6	0.0	0.0	6.3	7.5	4.2	3.3	3.5	1.1	7.5	2.1	1.6	37.7
Lat. 45° 4′ N.	1851	2.1	8.8	1.1	5.3	6.9	0.9	7.1	1.6	6.2	5.2	3.2	0.0	48.4
Long. 7° 40′ E.	1852	0.0	1.2	0.9	2.6	5.7	2.7	7.5	2.6	7.2	0.6	3.3	3.8	38.1
Mean Temp.	Mean	0.7	2.5	0.9	5.3	5.7	2.2	4.7	2.6	4.7	4.1	2.8	2.4	38.6
53.13° Fah.														
Florence.....	1845	4.5	2.7	5.8	5.5	5.4	2.2	0.2	2.5	5.3	2.3	5.5	3.1	45.0
	1846	0.6	0.2	3.8	3.3	1.5	0.9	1.3	3.7	3.5	9.5	5.4	5.2	38.9
Height 220 feet.	1847	4.1	2.4	0.2	4.4	1.4	3.2	2.9	4.9	1.8	2.0	0.7	2.0	30.0
Lat. 43° 41′ N.	1848	0.9	2.5	5.8	2.7	4.0	0.8	2.4	0.7	4.8	7.3	4.1	0.4	36.4
Long. 11° 15′ E.	1849	1.3	0.0	2.3	7.2	1.4	1.0	0.5	1.2	3.5	3.1	3.2	2.1	26.8
Mean Temp.	1850	0.9	0.9	0.6	4.3	3.1	1.9	2.3	2.6	3.0	9.6	5.3	2.8	37.3
59.24°	1851	0.8	0.8	3.1	3.8	3.8	1.3	1.7	3.1	4.6	9.5	12.9	0.3	45.6
	1852	1.9	1.6	0.9	4.8	0.5	1.5	1.5	1.8	2.7	4.7	3.6	2.1	27.6
	Mean	1.9	1.4	2.8	4.5	2.6	1.6	1.6	2.6	3.7	6.0	5.0	2.2	35.9
No. of Days		10.2	8.8	9.2	11.4	10.7	6.6	5.2	5.8	8.7	10.8	13.1	9.1	109.6
Naples	1851													39.6
	1852													25.2
	1853	2.4	11.3	7.6	1.1	1.4	1.1	0.0	1.0	2.5	3.5	4.5	10.7	47.1
Height 246 feet.	1854	4.9	0.7	0.8	1.5	5.2	1.2	1.7	0.5	0.5	4.3	12.1	5.3	38.7
Lat. 40° 51′ N.	1855	3.2	2.4	6.2	1.3	4.0	3.8	0.0	0.5	7.5	2.4	12.4	3.5	47.2
Long. 14° 15′ E.	1856	2.9	3.0	3.0	2.7	4.7	0.0	0.4	0.1	3.2	2.6	4.6	7.3	34.5
Mean Temp.	1857	11.6	0.6	4.2	1.7	1.6	1.6	0.9	3.7	2.9	6.2	2.3	0.4	37.7
60.26° Fah.	1858	1.7	6.5	4.5	1.2	2.2	1.5	1.0	5.4	2.3	7.7	7.8	3.9	45.7
	Mean	4.4	4.1	4.4	1.6	3.2	1.5	0.7	1.9	3.1	4.4	7.3	5.2	39.3
No. of Days		12.8	11.3	10.2	7.7	9.0	6.2	2.6	5.2	7.6	9.5	14.1	13.5	109.7
Maximum Rain in 24 Hours.	1854	0.8	0.5	0.8	0.8	2.3	0.5	0.8	0.2	0.5	1.6	1.1	1.3	
	1855	0.6	0.5	1.2	0.7	1.3	1.3	...	0.3	1.7	1.0	1.9	1.2	
	1856	0.7	0.8	1.8	1.9	1.7	...	0.4	0.1	1.2	1.1	2.1	2.5	
	1857	1.3	0.4	1.0	0.7	0.6	1.2	0.5	2.2	1.9	2.4	0.8	0.4	
	1858	0.5	1.8	1.0	0.9	1.6	1.2	0.4	1.89	0.7	2.0	1.4	2.0	

RAINFALL OF ROME AND JERUSALEM.

DETAILS OF MONTHLY FALL.

Period.		Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
	1821	4.1	2.1	3.2	2.5	1.7	4.5	0.2	0.2	0.9	4.2	1.2	1.6	26.4
	1822	4.8	1.7	4.2	5.3	3.3	1.6	0.1	0.2	4.1	8.7	4.2	5.3	43.5
	1823	4.3	5.3	4.4	4.5	0.6	0.2	0.0	0.1	4.5	10.7	7.1	1.8	43.5
	1824	5.2	3.3	3.8	2.3	0.2	0.1	1.5	1.6	4.1	9.4	4.2	5.3	41.0
	1825	0.6	0.1	2.5	4.2	1.9	6.0	1.9	0.8	5.3	5.6	9.2	8.7	46.8
	1826	1.6	2.3	2.7	2.2	3.8	2.0	0.8	0.4	2.9	2.9	11.2	0.8	33.6
	1827	5.7	2.8	1.2	0.9	2.3	3.1	1.0	0.8	3.5	3.5	2.4	0.7	27.9
	1828	1.6	2.7	2.1	1.4	1.5	1.6	0.0	0.0	0.7	3.8	2.1	0.5	18.0
	1829	6.4	0.2	1.9	2.3	1.7	3.1	0.3	0.9	4.8	3.1	4.1	5.5	34.3
	1830	5.4	1.7	0.2	0.0	1.8	0.3	0.4	3.0	3.6	1.9	1.7	8.6	28.6
	1831	3.6	0.6	1.0	5.0	3.6	0.7	2.2	1.1	4.1	2.4	2.7	1.7	28.7
	1832	3.8	2.1	3.6	1.4	1.3	4.6	0.2	0.8	0.2	0.3	3.1	1.4	22.8
	1833	0.5	2.3	2.1	4.8	1.0	0.1	1.7	0.6	7.5	2.4	2.2	0.8	26.0
	1834	1.2	1.4	0.0	0.2	2.9	0.1	1.6	0.5	0.8	1.0	2.8	0.5	13.0
	1835	4.7	0.7	2.3	1.2	2.7	4.1	0.6	3.5	3.0	1.3	2.1	1.4	27.6
	1836	0.4	5.8	1.7	3.5	3.9	0.5	0.2	1.6	5.2	2.8	2.7	2.5	30.8
	1837	2.7	1.5	4.2	2.7	3.3	0.4	1.1	0.5	2.7	1.3	3.2	1.5	25.1
	1838	4.4	5.3	2.3	3.3	2.0	0.8	0.9	0.7	1.6	4.1	2.9	3.1	31.4
	1839	2.4	0.4	5.0	1.9	1.5	0.4	0.9	2.6	15.4	4.4	3.2	4.4	42.5
Rome	1840	0.7	2.0	2.0	3.3	2.3	0.0	0.0	0.0	1.0	1.0	3.5	2.0	20.2
Height, 168 feet above the Sea.	1841	4.3	4.1	1.2	2.9	0.8	0.9	0.1	0.5	2.2	4.5	2.0	3.3	27.4
	1842	4.0	0.7	1.1	2.0	5.1	0.5	0.4	2.8	4.4	7.0	3.0	0.7	32.9
	1843	1.9	6.4	2.4	0.8	1.4	0.6	0.1	0.0	1.6	1.8	4.3	0.0	21.3
	1844	1.3	3.9	1.3	0.4	3.4	1.2	0.2	0.1	2.4	2.6	6.9	6.9	30.6
	1845	4.2	2.4	1.4	3.8	2.0	1.5	0.2	1.4	3.7	2.3	11.7	3.7	38.3
	1846	1.5	0.3	1.7	1.5	2.2	0.1	0.0	3.7	6.4	8.8	3.3	8.6	38.1
	1847	3.6	3.2	2.6	2.8	0.8	1.8	3.6	2.4	0.2	1.6	2.5	6.5	31.6
	1848	2.2	2.6	4.2	2.4	2.5	0.3	0.9	0.0	2.0	4.5	3.0	0.8	25.4
	1849													20.6
	1850	4.5	1.3	0.7	2.4	2.3	5.4	0.5	1.0	2.6	5.6	1.5	1.6	29.4
	1851	0.7	0.8	2.5	1.2	2.3	1.1	0.6	1.7	6.6	1.7	12.6	0.2	32.0
	1852	3.9	1.5	1.5	1.5	1.4	0.1	1.2	2.7	2.6	3.5	1.4	0.8	22.1
	1853	2.7	6.8	4.3	2.7	1.1	4.5	0.1	1.7	1.6	3.5	3.5	5.5	38.0
	1854	2.4	0.5	0.6	1.0	0.4	0.7	0.5	0.3	1.9	1.6	2.7	6.2	18.8
	1855	3.6	2.9	2.9	2.0	2.1	3.0	0.0	0.4	4.4	2.9	5.2	2.9	32.3
	1856	4.2	2.2	1.7	3.0	4.4	0.2	0.4	0.4	2.8	1.7	1.0	6.3	28.3
	1857	4.8	0.6	2.6	3.0	2.2	0.3	0.3	1.7	2.0	8.5	3.5	0.7	30.2
	1858	1.6	3.1	2.8	1.1	1.5	2.2	0.4	2.6	2.0	5.9	6.2	4.4	33.8
	1859	0.5	1.8	1.7	0.6	5.0	1.5	0.5	2.1	1.2	4.6	1.2	5.2	25.9
	1860	6.8	3.6	2.1	6.1	3.2	0.6	0.7	0.1	1.3	1.1	6.0	0.8	38.4
	Mean	3.2	2.4	2.3	2.4	2.2	1.5	0.7	1.2	3.3	3.8	4.1	3.3	30.4
	1846	6.0	7.4	5.4	0.0	0.0	0.0	0.0	0.0	0.0	4.0	6.4	0.0	29.2
	1847	9.8	32.8	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.0	67.6
	1848	24.6	5.8	0.0	0.2	1.4	0.0	0.0	0.0	0.0	0.0	0.2	16.0	48.2
Jerusalem ...	1851	14.6	24.0	4.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.2	60.0
2,749 feet above the Mediterranean, and 4,116 feet above the Dead Sea.	1852	13.6	25.0	8.8	0.0	2.4	0.0	0.0	0.0	0.0	0.0	1.8	9.4	61.0
	1853	4.2	4.0	21.4	1.2	2.0	0.0	0.0	0.0	0.0	0.0	6.0	12.4	52.2
	1854	13.2	20.0	24.8	10.8	0.0	0.0	0.0	0.0	0.0	3.8	0.0	6.4	79.0
	1855	32.6	13.0	8.8	2.4	0.0	0.0	0.0	0.0	0.0	0.0	1.0	3.2	61.0
	1856	17.6	21.8	10.2	24.8	0.6	0.0	0.0	0.0	0.0	0.0	14.8	4.2	94.0
	1857	13.0	57.2	4.0	4.0	1.0	0.0	0.0	0.0	0.0	1.4	6.6	17.0	104.2
	1858	23.2	23.6	1.6	5.2	shwr	0.0	shwr	0.0	0.0	0.0	0.0	21.8	75.4
	1859	11.2	8.2	16.8	6.2	0.0	0.4	0.0	0.0	0.0	4.4	2.8	0.8	50.8
	Mean	15.3	20.2	9.3	4.8	0.6	0.0	0.0	0.0	0.0	1.1	3.3	10.4	65.0
Mean Temp.....		47.7	53.7	60.0	54.7	66.7	71.7	77.3	72.5	72.2	68.4	58.9	47.3	62.6

RAINFALL OF AUSTRIAN EMPIRE.

DETAILS OF MONTHLY FALL.

Period.		Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Cracow	1850	0.7	1.5	0.9	1.3	0.9	1.3	5.2	9.6	4.0	4.1	3.7	0.7	24.9
	1851	0.2	0.5	0.7	1.8	1.6	3.9	5.1	4.4	4.6	2.7	2.7	2.8	31.0
	1852	2.2	4.0	1.3	1.5	3.7	0.6	8.4	11.5	0.9	4.4	9.4	2.4	56.3
	1853	1.1	1.3	2.4	2.5	2.0	4.1	4.6	1.9	2.8	1.4	0.6	2.3	27.0
	1854	1.2	2.5	1.6	0.7	1.6	3.8	6.2	3.0	0.6	1.5	1.5	2.1	26.3
	Mean	1.1	2.9	1.4	1.6	1.9	2.7	5.9	4.3	3.8	2.8	3.6	2.1	33.1
1826-1847, No. of Days		16	14	19	17	17	17	18	16	13	15	16	18	196
" " Temp.		23.2	29.3	39.3	50.7	61.0	68.4	70.5	68.0	60.4	49.8	35.4	34.7	48.8
Senftenberg	1850	2.3	4.8	2.3	2.6	3.7	3.3	4.7	4.0	1.8	4.7	3.6	2.5	40.3
	1851	0.7	0.7	3.4	2.2	2.1	2.5	4.3	4.8	4.3	3.0	5.4	2.6	36.0
	1852	2.9	5.2	1.2	0.7	1.2	3.6	2.3	3.6	2.1	1.4	1.5	1.4	27.1
	1853	2.0	0.8	1.1	3.6	2.4	4.3	4.3	2.8	2.7	1.7	0.7	1.6	28.0
	1854	2.3	4.2	3.2	1.8	3.3	7.0	3.3	9.1	0.7	2.7	3.0	7.2	47.8
	Mean	2.0	3.1	2.2	2.2	2.5	4.2	3.8	4.9	2.3	2.8	2.8	3.1	35.9
No. of Days		10	17	16	12	13	15	16	13	16	12	15	15	170
Prague	1845	1.1	0.9	1.7	1.9	3.4	1.1	2.4	1.5	1.8	0.1	0.5	1.2	17.6
	1846	1.4	1.1	1.0	1.0	1.7	1.8	2.8	2.0	1.6	1.5	0.5	2.2	18.6
	1847	0.7	1.2	0.4	1.6	2.5	4.8	3.6	3.8	2.2	1.9	0.4	0.4	23.5
	1848	0.3	1.6	0.8	1.9	1.2	2.1	2.5	1.5	1.6	1.2	2.1	0.2	17.0
	1849	1.1	0.6	1.3	2.3	2.7	2.8	0.7	1.0	0.5	1.7	0.5	0.6	15.8
	1850	0.8	1.5	0.4	0.9	2.8	2.9	2.1	2.2	0.3	2.7	0.8	0.4	17.8
	1851	1.0	0.4	0.8	1.3	1.4	1.5	2.0	2.7	2.7	0.8	3.4	0.4	18.4
	1852	1.0	0.9	0.1	0.5	1.6	2.7	0.5	4.1	0.7	0.4	1.4	0.4	14.3
	1853	1.5	1.3	0.8	2.7	1.7	4.4	1.6	1.0	1.8	0.8	0.9	0.6	19.1
	1854	0.3	0.6	0.3	1.0	1.2	3.2	1.5	2.8	0.4	1.0	1.0	0.8	14.1
	Mean	0.9	1.0	0.8	1.5	2.0	2.7	2.0	2.3	1.4	1.2	1.1	0.7	17.6
1804-50	Mean	0.8	0.5	0.9	1.1	1.7	2.3	2.0	1.8	1.3	0.8	1.0	0.9	15.1
	Min.	1.0	0.1	0.8	0.2	0.7	2.1	1.8	1.5	0.7	0.8	0.2	0.2	10.1
	Days	14	12	14	13	14	16	16	13	11	11	13	14	161
	Temp	28.2	31.8	38.5	49.1	59.0	61.4	68.0	71.8	59.9	50.0	39.4	33.1	49.2
Pürglitz	1850	0.8	0.9	0.3	1.6	1.5	4.5	1.5	1.8	0.5	3.4	1.0	0.4	18.2
	1851	0.8	0.4	1.2	2.9	2.3	1.9	3.5	1.7	2.5	1.3	2.2	0.2	20.9
	1852	0.8	0.9	0.2	0.9	1.4	4.0	0.3	4.8	1.8	0.5	2.0	0.5	18.1
	1853	1.3	1.6	0.9	3.7	2.2	4.4	2.3	3.1	1.9	1.1	1.0	0.9	24.4
	1854	0.4	0.9	0.6	1.5	2.0	4.4	1.7	2.9	0.4	1.1	1.6	0.8	18.3
	Mean	0.8	0.9	0.6	2.1	1.9	3.8	1.9	2.9	1.4	1.5	1.6	0.6	20.0
Schössl	1851	0.8	0.4	0.4	2.3	2.3	1.7	1.7	1.9	3.8	1.1	1.6	0.1	18.1
	1852	1.0	1.8	0.3	0.5	4.8	3.4	0.1	4.2	1.6	0.8	1.5	0.3	20.3
	1853	1.5	1.2	0.6	1.5	2.9	4.5	2.0	1.6	1.8	1.6	0.9	0.6	20.6
	1854	0.6	1.1	0.2	0.6	1.9	6.8	2.3	2.3	0.0	1.8	1.5	1.5	20.6
	Mean	1.0	1.1	0.4	1.2	3.0	4.1	1.5	2.5	1.8	1.3	1.4	0.6	19.9
Brünn	1850	1.5	1.5	0.3	1.7	1.9	3.7	1.9	0.8	1.1	3.0	0.9	0.5	18.8
	1851	0.3	0.4	0.8	2.1	2.9	1.3	4.3	2.0	4.0	1.2	3.9	0.6	23.8
	1852	1.1	0.9	0.3	0.2	1.6	1.6	1.0	1.6	0.4	0.7	0.7	0.5	10.6
	1853	2.4	1.3	1.4	1.2	1.7	4.6	2.7	2.3	1.1	0.3	0.3	1.7	21.0
	1854	1.2	1.2	0.4	0.8	2.4	2.6	2.9	5.2	0.4	2.2	1.0	1.5	21.8
	Mean	1.3	1.1	0.6	1.2	2.1	2.8	2.5	2.4	1.4	1.5	1.3	1.0	19.2
Pilsen	1848	0.2	1.3	0.9	2.0	1.7	1.4	2.2	2.8	1.2	0.8	2.0	0.2	16.7
	1849	0.6	0.8	0.6	2.9	2.1	2.2	1.6	1.9	1.6	3.5	1.3	1.2	20.3
	1852	1.0	1.2	0.5	1.0	0.8	3.3	1.2	1.3	0.9	0.6	1.6	0.3	13.7
	1853	1.9	1.2	0.7	2.1	1.6	3.4	1.5	1.4	0.9	0.5	1.3	0.6	17.1
	1854	0.3	0.3	0.7	0.9	0.9	3.2	1.2	1.9	0.3	1.2	0.4	0.9	12.6
	Mean	0.8	1.0	0.7	1.8	1.4	2.7	1.5	1.9	1.0	1.3	1.3	0.6	16.0

RAINFALL OF AUSTRIAN EMPIRE.

DETAILS OF MONTHLY FALL.

Period.		Jan.	Feb.	Mar.	April	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Stanislau	1845	0.4	1.3	1.6	0.8	4.0	1.4	4.7	9.1	1.5	1.3	1.4	0.7	28.2
	1846	1.4	0.9	0.6	1.8	2.1	2.7	3.3	2.3	3.5	0.5	0.5	1.5	21.1
	1847	0.3	0.8	0.5	0.3	0.5	2.8	3.2	3.4	1.5	4.1	0.4	0.1	17.8
	1848	0.8	0.9	1.2	1.0	0.9	6.0	5.2	1.7	2.9	2.1	1.3	1.9	25.9
	1849	0.8	1.3	1.8	2.4	2.7	4.4	2.4	3.9	1.6	1.9	2.6	1.7	27.5
	1850	1.9	2.2	0.7	1.5	2.2	1.2	2.0	2.2	3.7	3.5	1.8	1.6	24.5
	1851	0.2	0.9	0.9	0.9	3.5	3.7	5.9	4.8	4.5	0.9	2.1	1.6	29.9
	1852	1.0	1.1	0.6	2.8	5.2	1.6	3.1	2.4	1.9	4.1	1.5	0.5	25.8
	1853	0.7	0.8	1.4	2.9	2.9	2.7	5.7	4.0	1.4	3.5	2.1	1.3	29.4
	1854	0.9	1.5	2.1	0.3	1.1	4.6	3.4	3.2	2.0	0.6	1.9	1.2	22.8
	Mean	0.8	1.2	1.1	1.5	2.5	3.1	3.9	3.7	2.5	2.2	1.6	1.2	25.3
1840-50	Mean	0.8	1.0	1.2	1.6	2.5	3.6	3.6	3.3	2.4	1.9	1.3	1.1	24.3
	No. of Days...	8	8	10	9	11	12	13	10	10	10	8	9	118
	Mean Temp...	20.1	25.2	33.8	45.3	56.3	63.1	65.3	64.8	55.3	46.6	35.2	26.2	44.4
Smecna	1848	0.2	1.5	0.3	0.9	1.5	2.3	2.4	2.1	2.3	1.3	1.4	0.2	16.4
	1849	1.3	0.6	0.6	1.6	2.5	1.3	0.7	1.2	0.9	2.4	0.6	1.0	14.7
	1850	0.7	1.1	0.3	2.2	1.8	5.1	0.8	2.5	0.7	2.4	1.2	0.4	19.2
	Mean	0.7	1.1	0.4	1.6	1.9	2.9	1.3	2.0	1.3	2.0	1.1	0.5	16.8
Vienna ..... Max.	1845	0.6	0.6	2.8	1.3	3.3	0.8	2.1	1.3	2.1	0.4	0.3	1.5	17.1
	1846	1.1	0.4	1.4	1.9	0.7	0.8	3.2	5.2	1.5	1.2	1.0	2.4	20.8
	1847	0.9	1.2	0.1	2.9	1.6	4.1	1.1	1.6	1.7	4.4	0.3	1.2	21.1
	1848	0.6	1.0	0.7	1.1	1.6	2.8	3.6	2.4	0.9	1.5	1.0	0.0	17.2
	1849	2.3	0.7	1.5	1.3	2.1	1.3	0.6	4.1	0.3	1.2	1.0	2.3	18.7
	1850	2.7	2.6	0.2	0.9	1.0	4.2	1.2	0.3	0.3	1.9	0.9	0.6	16.8
	1851	0.1	0.1	0.8	1.4	4.8	0.8	2.7	2.6	4.2	0.7	2.4	0.4	21.0
	1852	1.2	1.3	0.4	0.5	0.6	1.5	0.9	2.5	1.1	1.3	2.1	0.5	13.9
	1853	2.0	1.1	2.6	4.0	1.6	6.8	2.5	1.7	2.2	0.4	1.3	1.0	27.2
	1854	1.7	1.8	0.9	0.2	1.0	2.1	4.1	4.2	0.6	2.7	0.9	2.0	22.2
	Mean	1.3	1.1	1.1	1.6	1.8	2.5	2.2	2.6	1.5	1.6	1.1	1.2	19.6
1843 Min.		1.2	0.4	0.5	1.4	1.3	1.8	2.4	1.0	0.7	1.0	1.2	0.4	13.3
1793-1850, No. of Days		14	12	13	11	11	13	13	12	10	10	12	13	144
1775-1850, Temp.		28.5	33.1	39.9	50.5	60.6	66.2	69.4	68.7	61.5	50.7	40.0	32.9	50.2
Linz	1852	1.8	2.7	1.1	0.2	1.5	1.6	4.0	2.3	1.1	1.8	1.1	1.3	20.5
	1853	1.5	0.4	1.4	3.4	1.8	5.6	3.1	2.2	0.3	2.0	0.8	0.9	23.4
	1854	1.0	2.2	1.0	1.3	1.9	4.4	2.4	3.2	1.1	1.5	1.5	2.8	24.3
	Mean	1.4	1.7	1.2	1.6	1.7	3.9	3.2	2.6	0.8	1.8	1.1	1.7	22.7
Kremsmunster ..... Max.	1850	2.8	4.4	1.8	5.4	3.0	9.3	4.8	3.3	3.5	6.3	3.9	3.6	52.1
	1851	0.7	1.3	2.7	4.5	6.8	4.3	6.3	7.2	3.9	0.9	4.9	1.7	45.2
	1852	1.5	3.1	1.8	1.2	3.9	3.3	5.4	6.0	2.7	3.2	2.4	1.1	35.6
	1853	1.8	1.2	3.7	6.7	2.0	8.2	5.2	4.5	1.9	1.7	2.2	0.9	40.0
	1854	1.3	3.5	1.7	2.9	1.9	6.3	5.1	5.3	1.5	2.3	2.0	4.1	37.9
	Mean	1.6	2.7	2.3	4.1	3.5	6.3	5.4	5.3	2.7	2.9	3.1	2.3	42.2
1820 to 1851, Mean.....		2.1	1.9	2.4	2.4	3.3	4.6	5.0	4.7	3.0	2.5	2.2	2.2	36 3
1822, Min.		3.3	0.9	3.8	0.5	2.3	1.1	2.8	4.2	1.9	0.9	1.0	0.4	23.1
1763-1850, Days		11	10	11	10	11	13	14	14	9	9	10	11	131
20 Years' Temp.....		26.3	28.5	36.9	47.2	55.3	61.0	64.4	63.3	56.5	46.8	37.0	30.2	46.1
St. Peter.....	1851	0.0	0.1	1.6	5.4	6.6	3.9	9.3	5.5	8.6	4.1	9.1	0.5	54.7
	1853	0.7	1.3	1.8	2.9	3.7	4.3	5.5	3.5	5.2	5.8	1.2	1.0	36.9
	1854	2.7	1.0	0.4	0.5	5.6	4.5	4.0	6.9	1.2	18.9	0.9	1.3	47.9
	Mean	1.1	0.8	1.3	2.9	5.3	4.2	6.3	5.3	5.0	9.6	3.8	0.9	46.5
Stubenbaak.	1848	...	...	...	12.2	3.8	7.2	10.6	5.9	3.9	10.2	14.9	2.7	...
	1849	6.1	10.6	3.7	9.1	5.5	9.0	3.5	6.7	5.7	8.2	3.5	12.0	83.6
	1850	5.2	16.8	6.4	5.0	3.6	10.6	5.3	3.4	0.5	9.5	12.2	10.5	89.0

RAINFALL OF AUSTRIAN EMPIRE.

DETAILS OF MONTHLY FALL.

Period.		Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Salzburg	1850	2.7	4.5	2.3	4.3	2.0	7.3	5.7	3.4	4.0	5.2	4.2	2.9	48.5
	1851	0.6	1.3	3.1	4.8	9.4	4.1	8.1	7.7	4.7	1.4	4.9	1.2	51.3
	1852	1.3	3.6	1.1	2.1	4.7	4.2	3.5	6.7	3.4	3.3	0.9	1.3	36.1
	1853	1.3	0.2	1.7	7.6	3.2	12.6	6.9	4.2	2.5	2.1	0.5	1.1	43.9
	1854	1.6	3.4	1.7	0.9	3.1	7.8	4.6	5.9	2.1	3.7	2.4	1.7	38.9
	Mean	1.5	2.6	2.0	3.9	4.5	7.2	5.8	5.6	3.3	3.1	2.6	1.6	43.7
Grätz	1837	1.1	0.1	1.2	2.2	6.2	3.5	7.6	4.6	2.3	1.3	4.5	0.6	35.2
	1838	2.0	1.3	1.2	2.2	3.9	5.2	5.4	4.2	2.8	1.5	2.4	0.7	32.8
	1839	1.0	0.8	0.8	2.1	2.5	5.2	0.9	4.2	2.7	2.3	2.2	1.3	26.0
	1840	0.5	1.2	0.1	0.6	2.8	5.2	3.8	2.6	2.7	1.9	2.0	0.9	24.3
	1841	1.6	1.8	0.4	1.4	1.0	4.6	4.6	4.8	2.5	4.1	0.8	1.9	29.5
	1842	1.9	0.1	1.5	1.4	3.9	1.1	4.0	2.4	6.6	4.2	3.0	0.1	30.2
	1843	2.0	1.1	2.0	2.6	2.9	3.6	2.6	3.3	1.5	3.9	1.5	0.0	27.0
	1844	1.0	2.9	0.9	0.1	3.9	4.7	7.2	5.2	2.0	3.5	3.4	6.8	35.6
	1845	2.1	2.7	2.1	4.1	5.7	4.7	4.2	7.2	3.5	0.5	1.0	1.9	39.7
	Mean	1.5	1.3	1.1	1.8	3.5	4.2	4.5	4.5	2.9	2.6	2.3	0.9	31.2
No. of Days.....		10	8	10	11	16	15	14	14	11	9	8	9	135
Temperature		26.6	34.7	37.2	48.5	58.6	65.1	67.3	68.1	59.9	48.2	40.3	33.8	49.0
Althofen	1851	0.0	0.0	1.2	1.6	3.5	3.5	3.6	6.6	3.3	1.3	7.1	0.0	31 7
	1852	0.6	1.2	0.5	1.0	3.0	3.0	3.8	5.1	3.7	6.2	0.9	1.6	30.6
	1853	0.7	2.3	1.7	3.2	1.8	4.3	5.3	2.3	4.4	3.6	1.4	1.9	32.9
	1854	1.5	0.2	0.2	0.5	4.6	4.8	2.3	4.7	0.8	3.6	1.4	0.4	25.0
	Mean	0.7	0.9	0.9	1.6	3.2	3.9	3.7	4.7	3.0	3.7	2.7	1.0	30.0
Klagenfurt..	1850	2.3	1.1	0.7	5.1	4.1	8.5	6.1	2.0	3.9	12.0	1.4	0.9	48.1
	1851	0.0	0.2	2.8	3.0	8.3	3.9	4.5	5.3	5.4	2.2	12.7	0.1	48.4
	1852	1.1	1.5	0.6	0.8	2.0	2.1	3.8	4.6	4.7	7.7	2.0	1.5	32.4
	1853	1.5	3.6	3.3	4.7	1.3	2.8	3.8	2.2	3.6	4.9	1.1	2.3	35.1
	1854	2.0	0.4	0.0	1.0	5.5	3.5	3.1	5.6	1.3	5.9	1.7	0.6	30.6
	Mean	1.4	1.3	1.5	2.9	4.2	4.2	4.3	3.9	3.8	6.5	3.8	1.1	38.9
Kronstadt ...	1852	1.3	1.7	1.0	4.3	3.4	4.4	4.8	2.1	1.7	2.9	1.1	0.4	29.1
	1853	0.4	2.7	2.3	3.1	2.1	4.8	3.5	1.5	1.3	0.8	1.0	0.6	24.1
	1854	0.7	2.4	1.8	2.7	1.7	7.8	6.1	2.8	3.4	1.2	2.7	2.7	36.0
	Mean	0.8	2.2	1.7	3.3	1.7	5.6	4.8	2.1	2.1	1.6	1.6	1.2	28.7
Bodenbach ..	1853	1.6	1.1	1.6	3.4	1.8	4.2	4.0	2.3	2.4	1.4	0.7	0.3	24.8
	1854	0.9	3.0	2.6	0.8	2.1	5.6	4.9	5.3	0.8	1.0	2.6	5.3	34.9
Rzeszow	1853	1.1	2.3	1.9	6.2	1.8	3.0	6.4	3.8	2.5	1.8	0.9	1.5	33.2
	1854	1.4	1.3	2.1	0.6	2.3	4.1	3.5	4.1	1.2	1.1	1.5	2.0	25.2
Saybusch.....	1852	...	...	1.7	1.1	2.7	2.5	5.0	6.2	2.0	1.4	2.3	0.5	...
	1853	0.9	1.6	1.9	4.0	1.7	5.8	7.9	2.9	2.8	0.5	0.9	0.9	31.8
	1854	1.7	2.8	2.8	0.4	4.1	4.5	6.5	7.7	1.3	1.0	...	...	...
Deutschbrod	1853	1.4	1.1	1.4	2.9	3.1	5.8	3.4	2.3	1.6	0.5	0.8	0.3	24.6
	1854	1.2	2.2	1.7	1.5	3.6	1.0	0.4	6.2	0.5	2.0	1.6	3.4	25.3
Czernowitz ..	1853	0.5	1.4	2.0	3.0	1.1	5.7	3.1	3.2	1.4	1.4	3.7	1.7	28.2
	1854	0.6	0.9	1.2	0.4	1.3	4.7	3.5	4.2	1.4	0.5	1.9	1.0	21.6
Schemnitz ...	1853	2.3	5.6	3.9	5.6	2.7	8.8	2.6	2.3	0.7	1.0	1.7	3.0	40.4
	1854	2.2	2.6	2.0	2.4	2.8	4.2	3.6	5.4	0.0	0.6	2.5	4.0	32.3
Gran	1852	...	2.3	0.5	0.1	5.3	2.3	5.4	5.6	3.6	4.7	2.1	0.1	...
	1853	2.0	1.3	1.4	1.9	...	...	1.2	1.9	1.7	1.6	0.9	0.6	...
	1854	0.5	0.3	0.2	0.3	1.3	0.8	1.0	2.1	0.0	0.9	1.5	6.1	15.0

RAINFALL OF AUSTRIAN EMPIRE.

DETAILS OF MONTHLY FALL.

Period.		Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Wallendorf..	1853	1.3	1.9	3.0	4.4	1.4	5.6	2.3	2.6	1.6	1.8	0.9	2.0	28.8
	1854	0.8	1.4	1.7	1.7	2.8	5.5	2.7	4.2	1.9	0.8	3.3	2.6	29.4
Alt Ausse ...	1852	...	...	2.1	2.7	6.8	6.3	6.2	10.5	3.4	4.5	6.1	2.6	...
	1853	2.2	1.3	3.2	15.1	2.5	11.6	9.0	7.9	3.5	3.3	3.0	0.7	63.3
	1854	6.4	10.3	4.6	2.5	2.9	9.2	5.8	10.9	2.7	3.8	6.6	13.1	78.8
Bregenz	1853	2.3	2.7	2.5	3.5	3.0	12.2	6.3	7.0	3.8	3.7	0.3	0.5	47.8
	1854	2.3	3.7	1.9	1.3	2.5	6.1	5.8	6.9	2.0	3.0	5.8	7.3	48.6
St. Paul.....	1853	1.1	3.3	2.6	3.0	1.6	5.3	3.5	1.9	2.6	4.0	1.3	1.3	31.5
	1854	0.8	0.2	0.1	0.8	4.3	3.9	3.5	4.3	1.4	3.0	0.9	0.7	23.9
Laibach	1853	3.6	10.4	6.7	7.3	4.5	3.9	1.4	6.2	5.8	9.6	3.7	7.8	70.9
	1854	4.0	1.3	0.1	4.0	7.0	4.7	3.4	6.5	2.9	7.7	8.2	5.2	55.0
Ober Vellach	1853	0.6	3.6	3.2	2.5	3.6	2.2	3.4	3.9	5.0	4.2	1.0	3.9	37.1
	1854	1.2	0.6	0.0	0.5	3.7	3.1	3.8	5.0	1.2	10.4	1.5	3.2	34.2
Hermann-stadt.....	1853	0.6	1.7	1.8	2.6	2.0	4.7	2.7	1.9	1.2	1.4	0.8	0.3	21.7
	1854	0.9	1.8	0.9	1.4	1.4	4.7	3.6	2.3	2.2	1.0	2.7	2.0	24.9
Max. 1764-1850	1845	8.2	2.6	4.9	1.3	5.2	5.8	3.5	6.2	2.8	2.8	8.8	1.2	53.3
	1846	1.1	0.1	2.2	4.9	5.2	2.9	2.7	7.7	6.8	12.0	3.5	3.5	52.6
	1847	4.7	0.3	0.0	4.0	1.6	2.5	4.6	6.3	1.6	3.8	1.4	5.4	36.2
	1848	2.2	3.4	5.9	5.9	1.9	3.7	3.1	2.9	5.2	10.4	5.0	0.4	50.0
	1849	0.3	0.6	3.5	8.9	3.5	1.1	0.8	6.8	0.6	4.5	1.6	6.2	38.4
Milan	1850	1.6	0.0	0.2	7.9	6.8	1.8	5.6	7.3	0.8	7.9	8.0	2.2	50.1
	1851	0.6	1.8	1.6	1.0	4.5	0.1	1.0	1.3	3.8	2.0	2.0	0.0	19.7
	1852	0.7	2.2	0.7	0.6	0.9	3.0	9.2	5.2	7.9	2.3	6.0	4.2	42.9
	1853	2.8	3.4	3.9	2.1	3.6	2.9	0.9	2.7	4.5	7.0	3.5	2.4	39.7
	1854	2.0	0.0	0.0	2.1	3.5	1.8	1.6	2.7	0.0	4.0	6.0	5.9	29.6
	Mean	2.4	1.4	2.3	3.9	3.7	2.6	3.2	4.9	3.2	5.8	4.6	3.3	41.3
1764-1850	Mean	2.7	2.4	2.4	3.3	3.9	3.1	2.9	3.4	3.5	4.5	4.3	3.1	39.5
	Min.	2.8	0.1	0.8	0.3	3.0	1.9	4.1	3.3	2.1	4.1	2.0	2.0	26.5
	Days	8	7	8	9	10	8	6	7	7	9	9	9	97
	Temp	33.4	38.5	46.6	54.9	64.2	70.7	74.8	73.2	66.4	56.1	44.1	35.8	54.9
Max. 1841-54..	1845	3.3	3.0	6.3	3.3	9.4	1.2	2.0	6.5	6.2	5.2	7.2	4.6	58.2
	1846	1.9	0.1	6.0	2.1	1.4	1.7	4.6	5.2	2.3	11.9	4.8	8.2	50.2
	1847	2.5	2.3	0.0	2.9	2.4	2.7	4.1	6.5	4.5	7.7	0.7	1.0	37.3
	1848	0.2	3.9	3.3	1.4	3.5	1.9	3.0	1.4	3.9	11.8	6.3	1.6	42.2
	1849	1.1	0.9	3.7	4.9	1.6	3.6	1.2	3.2	6.3	10.9	3.5	0.1	41.0
Trieste.....	1850	1.0	0.0	0.1	3.3	3.3	5.0	3.1	3.6	0.8	12.1	1.4	0.5	34.2
	1851	0.0	0.5	4.0	5.2	6.9	0.8	8.1	5.4	6.9	4.6	13.8	0.0	56.2
	1852	3.2	1.6	0.4	0.4	5.5	3.8	5.2	3.5	6.5	12.9	4.6	4.1	51.7
	1853	5.1	7.4	3.9	9.0	4.0	3.2	2.6	4.0	2.6	8.0	3.3	4.9	58.0
	1854	2.1	0.6	0.9	4.5	5.9	3.1	2.5	3.7	1.9	4.5	3.6	2.4	35.7
	Mean	2.0	2.0	2.9	3.7	4.4	2.7	3.6	4.3	4.2	9.0	4.9	2.8	46.4
1843 Min.		1.7	4.5	1.2	1.0	4.8	3.0	4.5	2.2	3.3	4.4	1.7	0.0	32.3
1841-50	Days	9	8	8	8	9	8	7	7	8	13	10	7	102
	Mean	2.1	2.3	2.4	2.4	3.6	2.7	3.1	3.5	4.6	8.4	4.3	2.4	41.8
	Temp	38.3	39.5	44.9	52.9	63.3	69.0	72.6	72.5	65.2	57.2	47.6	40.6	55.3
Venice	1854	1.2	0.1	0.2	1.9	3.0	2.4	0.5	0.7	0.3	2.8	1.2	2.7	17.0
	Days	7	1	1	7	14	10	3	4	2	9	7	8	73
Ragusa	1851	4.3	0.1	8.6	3.4	3.2	0.0	0.2	1.7	5.0	6.6	15.0	1.0	49.1
	1853	4.0	12.4	11.0	4.8	5.5	3.5	0.0	1.6	1.9	4.3	5.9	12.5	67.4
	1854	5.1	1.6	0.4	1.3	4.9	2.5	0.0	0.0	0.6	7.2	...	...	...

RAINFALL AT UDINE, LOMBARDY.—Lat. 46° 4″ N.; Long. 13° 16″ E.; Height, 359 feet.

	Mean Temp.	1803.	1804.	1805.	1806.	1807.	Mean of 5 Years.	1808.	1809.	1810.	1811.	1812.	Mean of 5 Years.	1813.	1814.	1815.	1816.	1817.	Mean of 5 Years.	1818.	1819.	1820.	1821.	1822.	Mean of 5 Years
	Fah.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	36.2	5.31	9.33	9.64	4.69	1.61	6.11	2.83	4.40	3.82	2.12	2.28	3.07	2.95	13.38	3.02	6.77	2.68	5.75	2.28	2.24	3.11	8.66	.79	3.42
February	39.2	1.69	3.43	2.24	3.77	3.38	2.87	1.69	3.35	4.88	.35	2.56	2.56	1.38	...	.23	3.11	.08	1.18	2.79	5.67	4.92	.08	.04	2.68
March	45.6	5.83	4.36	.39	6.02	3.86	4.09	...	1.50	4.92	.79	4.84	2.93	.43	3.70	1.10	2.36	.63	1.61	5.24	2.05	3.18	3.62	.90	2.99
April	53.8	1.73	5.55	2.56	7.24	6.76	4.72	2.79	14.52	3.03	10.83	4.76	7.15	4.72	1.97	3.77	4.17	2.32	3.38	3.15	3.31	8.97	4.21	3.74	4.68
May	63.7	5.79	5.16	6.81	4.48	3.11	5.03	3.90	2.20	5.20	4.76	5.39	4.29	4.17	7.52	4.92	7.95	9.84	6.88	5.98	5.71	5.00	7.00	4.72	5.67
June	69.6	8.94	5.31	4.57	5.16	5.27	5.82	9.96	3.54	3.43	8.03	3.94	5.74	7.83	9.84	8.11	12.70	4.72	8.62	5.03	6.25	12.05	4.84	2.24	6.09
July	72.8	11.81	11.96	6.81	3.78	3.66	7.59	5.08	12.71	8.15	3.98	10.83	8.14	15.48	3.54	10.80	9.96	3.66	8.66	4.45	3.31	6.89	8.00	3.78	5.26
August	71.9	5.12	4.65	7.76	8.77	2.04	5.63	3.74	2.24	6.69	3.35	9.96	5.19	2.95	10.94	5.79	7.95	3.47	6.22	7.91	8.04	5.12	5.75	4.68	6.30
September	65.2	10.55	1.50	3.78	10.77	6.93	6.69	6.22	6.14	.83	7.01	4.92	4.95	10.08	2.60	8.30	6.66	5.36	6.45	6.06	3.23	7.28	6.85	2.01	5.07
October	56.1	2.48	19.84	10.67	1.77	9.17	8.77	13.98	4.13	6.14	6.53	21.10	10.35	6.30	6.46	9.60	5.43	10.32	7.59	12.71	11.68	7.95	2.24	7.72	8.46
November	45.8	7.40	4.65	.20	5.06	13.11	6.06	4.69	8.03	8.31	.59	5.87	5.47	3.47	9.33	11.17	9.49	2.20	7.12	4.61	7.28	5.98	.99	1.61	4.09
December	39.1	7.46	9.84	5.43	3.22	3.62	5.90	1.93	11.02	4.88	1.69	3.50	4.60	8.19	3.03	2.71	1.93	4.33	4.02	1.97	2.87	2.83	8.31	5.94	4.37
Total and Mean.	54.9	74.22	85.58	60.86	64.73	62.51	69.56	56.81	73.82	60.28	50.07	79.95	64.21	67.99	72.33	69.56	77.91	49.61	67.49	62.20	61.64	73.28	60.54	38.18	59.12
Winter	40.1	21.96	27.72	26.38	14.07	13.30	20.93	21.25	14.37	27.76	15.68	7.13	17.20	13.74	25.04	15.61	23.77	14.17	18.47	11.61	14.48	18.19	17.56	10.12	14.37
Spring	58.2	22.28	20.34	14.32	22.83	19.01	19.68	16.65	21.76	16.58	24.44	18.93	19.64	17.16	23.03	17.91	27.19	17.52	20.55	19.40	17.33	29.20	19.68	11.60	19.44
Summer	66.5	29.96	37.95	29.02	25.11	21.76	28.76	29.02	25.22	21.81	20.87	46.81	28.74	34.81	23.54	34.49	29.40	22.80	28.98	31.13	26.25	27.24	22.83	18.19	25.11

RAINFALL AT UDINE, LOMBARDY.—(*Continued.*)

	1823.	1824.	1825.	1826.	1827.	Mean of 5 Years.	1828.	1829.	1830.	1831.	1832.	Mean of 5 Years.	1833.	1834.	1835.	1836.	1837.	Mean of 5 Years.	1838.	1839.	1840.	1841.	1842.	Mean of 5 Years.	Mean of 40 Years
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January	4.33	.28	2.83	1.65	5.94	3.00	.39	5.47	1.22	2.01	3.70	2.55	.43	5.12	2.91	2.91	1.89	2.64	5.36	1.89	1.85	5.39	2.72	3.43	3.74
February....	6.97	2.64	.04	2.99	5.20	3.54	2.71	.39	2.52	1.77	7.40	2.95	3.15	1.46	2.91	13.54	4.65	5.15	5.27	2.16	3.47	3.11	.63	2.91	2.95
March	3.31	2.83	2.71	3.58	4.68	3.42	3.58	3.94	.24	1.49	6.22	3.08	6.18	.04	2.16	6.69	6.57	4.33	6.02	7.99	....	.83	1.18	3.19	3.19
April	4.29	3.39	.43	1.89	7.25	3.42	3.50	7.79	2.72	5.20	1.73	4.18	13.34	1.97	5.47	6.93	4.57	6.45	6.42	4.09	.71	1.18	1.89	2.83	4.60
May	4.76	6.81	5.24	7.21	9.21	6.65	4.84	2.36	3.15	7.91	8.26	5.31	2.09	2.16	2.83	4.79	10.89	4.53	10.39	7.91	9.53	2.83	8.23	7.79	5.82
June.....	8.23	8.74	7.87	2.95	12.01	7.95	4.80	3.90	10.08	6.34	8.19	6.65	4.84	3.35	6.54	7.09	2.36	4.84	6.73	4.41	7.09	8.19	7.05	6.69	6.53
July	8.66	5.20	6.97	10.20	1.50	6.49	4.14	2.95	1.73	4.37	5.82	3.78	14.77	3.47	2.40	8.47	7.76	7.36	9.05	2.01	3.35	3.66	5.79	4.76	6.49
August	1.46	2.76	6.14	4.65	7.32	4.44	2.52	5.36	3.39	8.46	1.81	4.29	7.32	5.43	10.59	1.30	3.35	5.59	2.83	6.96	7.69	2.52	.98	4.18	5.23
September..	12.79	5.04	5.39	4.02	7.40	6.92	10.98	10.63	9.41	8.19	2.01	8.22	9.65	.39	9.13	6.10	3.54	5.75	4.14	11.25	8.90	4.64	10.90	7.99	6.49
October.....	10.94	9.92	3.78	8.62	4.33	7.51	7.83	5.28	.90	4.68	2.52	4.25	4.92	1.45	4.37	9.61	4.25	4.92	1.93	1.50	4.64	10.59	4.56	4.64	7.08
November...	.43	2.68	7.12	20.86	.47	6.30	10.82	3.90	6.30	1.30	6.57	5.78	5.15	2.60	2.91	1.30	9.80	4.37	8.55	13.19	7.00	1.02	6.57	7.25	5.82
December...	3.90	3.35	15.52	1.33	1.18	5.03	3.70	4.72	8.66	1.81	1.34	4.05	.86	.31	.16	5.36	2.36	1.81	5.24	3.55	1.73	5.83	.15	3.30	4.13
Total	70.08	53.63	64.04	69.96	66.49	64.80	59.83	56.69	50.35	53.54	55.59	55.12	72.72	27.75	52.41	74.06	62.00	57.75	71.93	66.93	55.94	49.79	50.62	59.97	62.08
Winter	18.86	7.25	8.89	27.28	33.34	19.10	4.76	20.38	12.36	18.74	14.21	14.09	11.48	12.59	8.73	19.52	13.19	13.10	22.79	17.84	22.05	17.24	10.20	18.00	16.86
Spring	20.59	21.77	16.25	15.63	33.15	21.45	16.73	17.99	16.21	20.93	24.41	19.25	26.42	7.51	17.00	25.47	24.40	20.14	29.56	24.41	17.33	13.02	18.32	20.51	20.07
Summer	33.86	22.91	22.28	27.48	20.55	25.39	25.47	24.21	15.43	25.70	12.16	20.59	36.65	10.74	16.49	25.47	18.90	23.65	17.95	21.72	24.57	21.41	22.23	21.56	25.34

RAINFALL OF FRANCE.

DETAILS OF MONTHLY FALL.

Period.		Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Paris..... 205 feet.	1838	0.1	1.9	2.3	1.6	1.9	3.2	1.2	1.7	3.5	1.2	3.9	1.1	23.6
	1839	2.1	2.6	1.2	1.0	1.3	4.6	1.3	1.1	3.9	2.5	2.4	2.1	26.1
	1840	2.4	0.7	0.3	0.3	1.3	1.1	1.4	1.3	4.9	1.8	2.9	0.0	18.4
	1841	1.9	1.0	1.6	1.5	1.8	2.0	3.9	1.6	1.6	2.9	2.4	2.8	25.0
	1842	1.1	1.3	1.3	1.0	1.0	1.6	0.6	0.6	3.4	1.1	2.4	0.2	15.6
	1843	2.5	3.2	0.2	2.6	2.5	2.6	2.4	1.9	1.0	2.0	3.2	0.2	24.3
	1844	1.5	2.7	1.8	0.2	3.1	1.5	3.6	3.0	3.6	2.1	2.6	1.2	26.9
	1845	2.0	1.5	1.3	1.9	2.3	3.2	1.9	1.9	3.0	1.4	2.9	3.1	26.4
	1846	3.0	0.8	2.1	2.9	1.7	1.5	0.9	3.4	2.6	3.5	1.7	2.3	25.8
	1847	1.9	1.4	0.9	1.8	1.2	1.1	4.5	1.9	1.1	1.5	1.1	1.3	19.7
	1848	1.1	1.8	2.2	4.0	0.8	2.5	2.0	4.4	0.8	2.1	1.5	1.6	24.8
	1849	2.1	0.7	1.2	2.5	2.6	3.4	2.9	1.1	3.3	1.9	2.6	1.9	26.2
	1850	2.0	1.2	0.8	2.2	2.4	0.9	1.7	6.2	1.3	2.5	2.0	2.0	25.2
	1851	1.7	0.8	3.0	2.9	1.4	0.5	3.4	1.1	1.2	1.9	1.7	0.7	20.3
	1852	2.5	0.7	1.4	0.9	2.7	2.9	1.4	2.2	3.0	3.4	2.4	2.1	25.6
	1853	3.2	0.7	1.2	2.7	1.9	1.8	1.9	2.8	1.3	2.2	0.4	1.5	21.6
	1854	1.9	0.9	0.1	1.1	1.8	7.7	4.1	1.8	0.5	3.0	2.5	2.3	27.7
	1855	1.1	1.4	1.8	0.4	1.0	2.1	1.6	1.5	0.5	2.4	1.1	0.8	15.7
	1856	1.8	0.3	1.4	2.3	1.4	2.0	2.3	2.2	2.8	1.1	2.1	1.3	21.0
	1857	2.5	0.6	1.0	2.2	2.2	2.9	0.5	2.5	3.0	2.3	0.4	1.5	21.6
	Mean	1.6	1.3	1.4	1.8	1.8	2.5	2.2	2.2	2.3	2.1	2.1	1.5	23.1
Mean Temp.		35.4	39.5	44.0	49.8	58.1	62.7	65.7	65.4	60.2	52.2	44.2	38.6	51.3
Versailles ...	1847	1.6	1.4	0.7	2.0	1.7	1.3	6.5	1.4	1.2	1.7	1.4	1.1	22.0
	1848	0.6	3.0	3.1	4.4	0.9	1.7	2.2	2.8	0.5	2.0	1.5	1.4	24.1
	1849	2.1	0.4	1.1	2.6	2.7	1.8	2.8	0.5	2.8	2.1	1.7	1.4	22.0
	1850	2.0	1.2	0.5	2.4	1.9	0.7	1.0	4.7	1.4	2.6	1.9	1.4	21.7
	1851	2.0	0.3	3.0	2.5	1.2	0.5	3.3	1.2	0.9	1.8	1.4	1.0	19.1
	1852	2.5	0.8	1.3	0.9	3.0	2.7	0.5	2.6	2.6	3.0	2.7	2.0	24.6
	1853	2.9	0.8	1.1	2.8	2.2	3.4	1.2	2.1	0.9	2.1	0.6	0.5	20.6
	Mean	2.0	1.1	1.5	2.5	1.9	1.7	2.5	2.2	1.5	2.2	1.6	1.3	22.0
Rouen	1845	1.9	3.5	3.1	3.9	3.7	3.8	2.4	2.2	3.9	1.5	3.2	5.4	38.5
	1846	3.3	4.3	2.5	3.7	2.1	1.7	1.0	3.8	3.0	5.8	1.6	2.9	35.7
	1847	4.1	3.0	1.1	4.5	2.3	2.2	2.2	4.2	2.5	2.0	2.8	2.8	33.7
	1848	1.8	2.8	5.0	4.0	0.7	2.7	2.2	4.6	3.1	2.4	2.9	2.3	34.5
	1849	4.4	1.6	0.4	2.9	2.4	3.3	2.6	1.5	2.7	3.0	3.0	3.2	31.0
	1850	2.0	1.3	1.1	1.5	1.2	1.2	1.2	3.7	2.0	4.1	1.4	3.8	24.5
	1851	2.0	1.8	6.3	2.3	1.4	1.3	3.1	5.2	1.6	3.1	2.7	2.0	32.8
	1852	3.9	1.1	0.8	0.1	4.5	6.2	2.2	4.8	2.1	5.7	3.8	3.5	38.7
	1853	2.9	1.9	0.7	3.2	5.0	3.6	5.2	1.6	4.1	4.3	1.3	1.5	35.3
	1854	2.3	1.0	0.5	1.1	4.4	4.7	3.4	2.1	0.8	3.5	3.0	5.5	32.3
	Mean	2.9	2.2	2.1	2.7	2.8	3.1	2.5	3.4	2.6	3.5	2.6	3.3	33.7
Metz ..... (Moselle.)	1840	3.7	1.1	0.2	0.2	2.7	1.2	1.9	2.2	3.7	4.2	5.4	0.2	26.7
	1841	2.3	0.5	0.9	1.6	2.4	2.9	2.0	4.0	3.0	5.3	3.4	4.2	32.5
	1842	0.3	0.0	2.0	1.9	1.6	1.0	2.4	2.5	2.3	1.3	2.4	1.3	19.0
	1843	5.3	2.6	1.0	2.3	2.3	2.7	3.7	2.4	1.5	3.4	2.7	0.6	30.5
	1844	2.1	3.7	3.1	1.4	2.3	1.5	4.7	3.2	1.8	2.1	2.8	1.7	30.4
	1845	1.9	0.6	1.5	1.5	2.0	2.2	3.1	3.7	3.6	1.8	2.5	4.2	28.6
	1846	4.5	1.5	2.7	3.9	3.4	1.3	2.4	1.0	1.4	2.5	3.0	1.6	29.2
	1847	2.0	1.9	0.3	2.7	1.3	2.6	3.5	2.7	1.7	1.2	1.2	1.1	22.2
	1848	0.2	4.0	3.8	4.7	0.7	4.7	1.3	5.2	2.6	2.9	3.1	2.4	35.6
	1849	2.9	1.8	0.7	2.4	3.8	2.5	4.2	2.0	1.8	3.4	1.5	2.6	29.6
	Mean	2.5	1.8	1.6	2.3	2.2	2.3	2.9	2.9	2.3	2.8	2.8	2.0	28.4
1825 to 1846 Mean		1.9	1.5	1.8	1.8	2.1	2.0	2.5	2.6	2.4	2.2	2.8	2.3	25.9
Mean Temp.		38.1	41.0	52.9	50.4	66.0	70.7	75.2	76.1	68.9	56.1	41.7	38.8	56.3
Angers.....	1852	4.2	1.3	1.4	0.8	4.1	4.3	2.0	3.8	3.3	3.4	4.0	4.2	36.8
	1853	5.4	1.8	1.6	1.6	3.3	2.3	2.2	4.7	1.6	4.9	2.4	1.0	32.8
	1854	2.8	0.6	0.3	1.5	2.8	3.2	1.2	1.2	0.4	3.9	3.8	1.5	23.2
	Mean	4.1	1.2	1.1	1.3	3.4	3.3	1.8	3.2	1.8	4.1	3.4	2.2	30.9

RAINFALL OF FRANCE.

DETAILS OF MONTHLY FALL.

Period.		Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
La Chapelle (Near Dieppe.)	1839	2.9	3.8	2.5	1.3	1.9	6.1	1.7	1.7	4.6	3.1	3.0	4.5	37.1
	1840	3.0	1.5	0.6	0.4	2.0	1.0	3.9	3.1	4.7	3.7	4.0	0.2	28.1
	1841	3.4	1.3	1.7	2.6	2.3	2.5	6.2	3.8	2.7	5.5	4.7	4.1	40.8
	1842	1.1	1.4	2.6	1.1	1.4	2.3	1.2	0.8	3.5	4.0	3.7	1.1	24.2
	1843	3.4	3.0	0.5	3.0	5.8	3.4	2.5	3.0	1.5	2.3	3.4	0.5	32.3
	1844	1.9	4.2	3.2	0.7	2.0	2.4	2.5	4.1	1.7	3.3	1.8	0.8	28.6
	1845	2.3	2.5	1.3	2.6	4.5	2.5	3.5	3.3	5.7	1.3	2.5	3.3	35.3
	1846	3.9	0.7	2.9	3.7	1.4	1.7	1.9	2.6	2.5	6.3	1.8	2.9	32.3
	1847	1.2	2.7	1.0	2.4	2.5	1.1	5.2	4.6	3.4	1.3	2.3	2.2	29.9
	Mean	2.6	2.3	1.8	2.0	2.6	2.6	3.2	3.0	3.4	3.4	3.0	2.2	32.1
Cambrai	1850	0.6	1.3	0.6	1.7	1.3	1.8	1.2	7.3	1.2	1.2	1.7	1.3	21.0
	1851	0.2	3.1	3.0	3.1	0.6	2.4	1.6	2.2	2.4	1.8	2.9	1.4	24.7
Saint Lo	1844	3.2	4.6	2.5	0.7	2.0	2.0	2.9	2.9	2.2	4.9	2.9	0.7	31.5
	1845	2.6	2.8	1.2	2.3	1.9	1.6	3.1	2.1	4.9	1.1	2.3	4.3	30.2
	1846	4.5	0.8	2.8	3.5	2.7	3.4	1.8	1.4	3.3	4.6	1.2	2.3	32.3
	Mean	3.4	2.7	2.2	2.2	2.2	2.3	2.6	2.1	3.5	3.5	2.1	2.5	31.3
Cherbourg	1850	2.9	3.5	0.9	3.9	3.5	2.9	2.1	5.9	3.8	5.5	6.5	4.8	46.2
	1851	5.3	1.1	7.2	2.4	0.7	1.3	1.8	1.6	0.5	4.9	4.2	2.2	33.2
Brest	1831	4.0	3.2	3.1	3.6	3.7	0.8	1.8	1.1	2.1	5.5	2.8	5.1	36.8
	1832	3.3	1.4	3.3	1.8	1.8	2.1	0.8	5.7	0.6	2.7	6.7	4.9	35.1
	1833	2.2	7.8	4.3	2.9	0.6	2.2	1.7	0.8	2.9	3.1	2.7	5.6	36.8
	1834	7.6	2.8	0.7	0.7	1.8	1.7	3.0	2.5	2.3	1.2	2.5	0.8	27.6
	1835	1.7	4.7	3.2	2.4	2.6	1.3	0.9	1.3	6.0	6.2	3.3	1.2	34.8
	1836	3.7	3.4	5.3	6.9	0.7	2.5	1.7	0.6	3.9	4.6	8.7	3.7	45.7
	1837	5.2	5.1	2.2	7.3	0.6	0.9	2.4	5.9	4.3	2.6	4.2	3.3	44.0
	1838	1.9	3.7	4.5	4.4	3.3	4.6	1.8	2.0	2.2	4.6	8.4	4.9	46.3
	1839	4.8	5.1	3.3	1.1	2.1	3.7	3.5	3.0	6.8	3.6	6.7	8.6	52.3
	1840	5.2	3.1	0.5	0.6	2.5	0.9	2.4	2.4	4.3	2.7	6 3	1.4	32.3
	Mean	4.0	4.0	3.0	3.2	2.0	2.1	2.0	2.5	3.5	3.7	5.2	4.0	39.2
1810 to 1840 Mean		3.9	3.4	3.0	2.9	2.3	2.1	2.3	2.3	3.2	4.1	4.7	4.6	38.8
Nantes	1849	1.9	1.0	0.8	3.4	3.0	2.1	1.7	0.3	6.0	1.9	3.9	2.4	28.4
	1850	1.7	0.8	0.4	3.4	2.5	0.7	1.4	2.1	1.7	2.0	2.0	2.3	21.0
	1851	...	...	...	...	...	...	...	...	...	...	...	...	19.5
	1852	4.3	0.9	0.9	0.2	2.9	3.5	2.4	3.7	2.6	3.4	3.4	2.6	30.8
	1853	6.3	1.3	0.5	1.5	2.8	3.0	1.8	3.6	1.6	3.4	1.1	1.0	27.9
	Mean	3.5	1.0	0.6	2.1	2.8	2.4	1.8	2.4	3.0	2.7	2.6	2.1	27.0
Bordeaux	1842	2.9	2.9	2.9	1.5	0.9	1.8	1.1	8.6	3.4	2.9	4.8	0.7	34.4
	1843	7.1	3.1	0.9	4.3	3.0	3.1	1.8	2.3	3.0	3.6	1.6	0.4	34.2
	1844	3.5	6.4	1.1	1.3	0.7	2.7	0.4	5.2	4.4	5.4	3.2	1.3	35.6
	1846	3.7	0.0	4.3	2.8	2.7	2.3	2.5	0.0	3.3	6.9	5.2	3.3	37.0
	1847	1.7	3.3	2.3	2.8	2.4	0.8	1.2	3.4	0.5	2.6	3.7	3.4	28.1
	1848	1.6	5.6	4.2	4.6	1.9	4.1	1.1	1.8	1.5	4.4	2.2	1.8	34.8
	1849	3.2	0.2	2.4	4.2	1.8	0.8	3.2	2.2	5.6	2.8	4.9	2.4	33.7
	1850	2.7	2.3	0.5	2.9	2.6	0.8	3.1	4.9	2.6	5.2	2.5	2.6	32.7
	1851	2.5	2.6	1.0	3.1	3.7	1.9	0.4	2.7	0.3	1.0	3.2	3.2	25.6
	1852	2.2	1.3	0.5	1.5	2.7	3.7	2.9	5.7	3.0	2.4	2.7	2.3	30.9
	Mean	2.8	2.5	1.8	2.6	2.0	2.0	1.6	3.4	2.5	3.4	3.1	2.0	29.7
Toulouse	1845	4.1	1.2	2.6	1.8	3.9	4.5	1.1	2.1	2.5	1.2	1.9	2.0	28.9
	1846	1.7	0.4	1.1	2.8	2.9	3.4	1.3	3.4	1.6	3.7	0.7	2.1	25.1
	1847	0.7	1.7	1.0	2.3	1.0	1.2	0.2	3.0	0.6	2.3	2.0	2.6	18.6
	1848	2.1	1.1	0.5	2.6	1.8	2.7	0.4	0.1	6.0	6.2	0.8	0.8	25.1
	1849	2.3	0.3	0.7	3.8	1.0	2.0	1.5	0.9	3.1	2.0	2.3	1.2	21.1
	1850	2.3	1.4	0.5	3.4	2.4	1.1	1.9	4.5	1.1	2.5	1.3	0.9	23.3
	1851	2.7	2.0	1.5	2.6	2.9	1.0	1.8	0.6	1.7	2.4	3.2	0.6	23.0
	1852	1.0	1.2	0.4	1.8	2.4	2.7	2.0	2.1	0.7	2.4	1.1	1.7	19.5
	1853	1.9	1.8	1.1	1.6	4.2	4.3	0.7	1.1	2.3	3.2	1.3	1.0	24.5
	1854	0.9	0.5	0.2	0.9	1.8	5.5	0.5	1.7	0.1	1.5	2.3	1.4	17.3
	Mean	2.0	1.2	1.0	2.4	2.4	2.8	1.1	1.9	2.0	2.7	1.7	1.4	22.6

RAINFALL OF FRANCE.

DETAILS OF MONTHLY FALL.

Period.		Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Goersdorff ... (Lower Rhine.)	1845	2.7	2.7	3.3	2.6	3.0	4.1	5.9	5.9	6.3	3.5	2.2	6.8	49.0
	1846	6.3	3.9	4.5	4.0	5.5	0.7	2.7	3.4	1.2	3.7	4.7	4.1	44.7
	1847	2.1	3.9	0.8	3.9	2.3	3.7	2.6	4.8	1.9	3.2	1.1	1.9	32.2
	1848	1.2	7.9	6.3	6.5	0.2	2.2	1.0	3.0	2.0	2.8	5.5	1.9	40.5
	1849	3.9	1.5	1.7	3.1	3.6	3.6	6.7	0.8	2.1	3.9	2.2	2.9	36.0
	1850	2.2	5.2	1.1	3.5	1.5	2.4	2.2	4.8	2.6	1.7	1.7	1.6	30.5
	1851	1.3	0.5	4.8	2.4	3.0	1.2	6.3	4.8	4.9	2.0	1.8	0.5	33.5
	1852	3.7	2.9	0.3	0.7	2.9	4.6	2.4	8.3	3.8	3.5	3.6	2.9	39.6
	1853	4.4	1.5	1.1	4.3	4.6	5.0	2.7	1.3	3.3	2.8	0.4	0.9	32.3
	Mean	3.1	3.3	2.7	3.4	3.0	3.1	3.6	4.1	3.1	3.0	2.6	2.6	37.6
Saulsai	1852	0.6	0.5	0.5	0.3	1.5	8.5	6.9	11.9	2.3	5.1	6.0	0.1	44.2
	1853	2.5	1.0	0.7	1.8	4.8	2.8	1.6	3.1	3.4	4.3	2.1	1.2	29.3
	1854	1.0	0.5	0.1	1.1	4.5	8.2	2.9	3.2	0.0	2.9	3.7	0.9	29.0
	1855	1.3	5.6	1.9	0.9	3.6	2.8	2.0	1.2	2.6	9.1	1.2	2.6	34.8
	1856	2.7	0.7	1.7	6.2	11.4	3.9	0.6	4.2	4.8	1.2	2.0	4.5	43.9
	1857	1.5	1.0	0.3	2.9	3.7	2.5	2.0	2.9	2.5	3.8	0.8	1.3	25.2
	1858	0.1	1.4	2.2	1.8	3.5	0.6	2.8	2.2	2.3	4.6	3.7	2.9	28.1
	Mean	1.4	1.5	1.1	2.1	4.7	4.2	2.7	4.1	2.6	4.4	2.8	1.9	33.5
	Days	7	6	8	12	15	9	8	7	11	10	7	6	100
Saulsai Evaporation...	1856	1.2	0.9	1.4	2.9	4.0	5.5	6.1	5.6	3.0	1.1	0.1	0.4	32.2
	1857	0.3	0.3	1.5	2.9	4.2	5.6	7.0	5.7	2.2	1.7	0.7	0.5	32.6
	1858	0.0	0.2	1.1	2.3	2.4	5.0	5.4	4.6	2.9	1.6	0.5	0.5	26.5
	Mean	0.5	0.5	1.3	2.7	3.5	5.4	6.2	5.3	2.7	1.5	0.4	0.5	30.5
Privas	1843	0.9	3.4	0.5	0.8	5.1	10.2	0.5	2.0	4.0	2.7	18.2	2.9	51.2
	1844	1.3	1.5	3.2	1.3	2.2	2.4	2.4	1.6	12.0	9.6	5.9	5.8	49.2
	1845	5.1	0.2	2.8	2.8	3.2	2.6	0.7	3.7	3.9	2.0	10.6	1.8	39.4
	1846	2.4	0.1	3.4	2.1	6.8	6.5	0.8	2.8	17.2	15.7	5.3	3.1	66.2
	1847	4.1	0.3	1.6	6.2	3.9	0.7	0.7	2.0	0.6	8.4	8.8	1.8	39.1
	1848	0.6	1.8	4.5	10.6	3.2	7.5	2.4	0.8	11.1	9.4	2.7	3.1	57.7
	1849	0.7	0.1	3.7	6.4	2.7	4.6	2.6	2.8	13.6	8.1	3.7	1.6	50.6
	Mean	2.2	1.1	2.8	4.3	3.9	4.9	1.4	2.2	8.9	8.0	7.9	2.9	50.5
Viviers	1820	1.8	4.6	1.4	2.7	2.0	0.2	0.5	2.3	1.9	5.8	5.3	1.4	29.9
	1821	4.6	0.3	6.9	3.4	1.6	0.4	4.6	1.1	2.6	3.0	0.6	2.9	32.0
	1822	0.3	0.1	0.1	1.4	3.8	0.2	2.6	2.3	3.3	3.9	5.6	2.3	25.9
	1823	3.8	2.6	3.0	5.2	1.4	4.9	4.5	0.2	8.4	6.6	0.6	0.8	42.0
	1824	0.8	4.4	1.1	0.8	2.4	8.0	0.3	0.8	6.0	9.8	2.7	0.6	37.7
	1825	0.4	0.4	0.9	0.4	3.1	1.6	1.0	0.9	2.9	1.9	7.5	5.6	26.6
	1826	0.0	2.4	3.4	0.2	2.3	0.5	7.1	2.5	6.2	4.8	7.1	3.9	40.4
	1827	1.2	4.0	1.5	3.1	3.9	1.8	0.4	2.2	9.8	4.9	0.8	3.2	36.8
	1828	0.6	2.3	0.8	3.4	3.7	0.4	2.3	4.0	5.9	4.0	2.8	1.1	31.3
	1829	5.8	0.7	3.9	4.0	4.3	2.5	0.7	2.6	2.5	3.2	3.7	2.4	36.3
	Mean	1.9	2.2	2.3	2.5	2.8	2.1	2.4	1.9	4.9	4.8	3.7	2.4	33.9
Mean of 52 Years.....		2.5	1.8	2.1	2.9	3.3	2.6	2.0	2.4	4.6	5.0	4.5	2.6	36.3
Max. Year 1801		2.2	3.5	0.1	1.8	4.3	2.3	0.8	1.3	0.3	13.3	13.2	3.1	52.2
Min. Year 1779		0.6	0.2	0.1	0.2	2.3	3.4	1.4	5.2	0.5	4.7	2.6	1.3	22.5
Marseilles ...	1845	4.0	0.3	2.1	1.3	1.2	1.3	0.5	1.7	0.3	0.1	3.0	1.6	17.4
	1846	2.0	0.0	1.4	1.4	1.1	0.9	0.1	1.6	4.4	5.7	1.4	2.0	22.0
	1847	1.4	0.5	1.7	0.9	0.8	1.3	0.0	1.4	0.5	4.5	2.0	1.0	16.0
	1848	2.1	1.1	0.5	2.6	1.8	2.7	0.4	0.1	5.9	6.3	0.7	0.8	25.0
	1849	1.0	0.2	1.8	2.2	0.8	0.2	0.1	0.0	2.0	1.3	3.0	2.2	14.8
	1850	3.0	0.0	0.1	1.8	2.8	1.0	0.0	1.0	0.7	1.4	1.9	0.5	14.2
	1851	1.5	5.4	0.5	1.8	1.3	0.1	0.9	0.0	1.8	4.1	2.2	0.2	19.8
	1852	1.0	0.3	0.2	1.5	0.9	1.7	0.4	1.3	3.5	2.0	3.2	0.4	16.4
	Mean	2.0	1.0	1.0	1.7	1.3	1.1	0.3	0.9	2.4	3.2	2.2	1.1	18.2
Mean Temp.		43.2	45.4	48.4	56.1	63.2	71.0	75.9	71.9	68.7	58.7	50.2	47.1	58.3
Alais.....1802 to 1836		3.4	2.4	2.4	3.3	3.6	1.8	2.1	1.7	5.2	5.5	4.4	3.2	39.0

RAINFALL OF FRANCE.

DETAILS OF MONTHLY FALL.

Period.		Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Bourbonne... 1,089 feet above the Sea.	1852	2.2	2.0	0.0	0.2	2.0	5.2	1.9	5.6	3.1	2.7	4.6	0.8	30.3
	1853	3.5	1.1	0.4	3.2	2.3	3.1	1.6	1.0	2.2	3.0	0.6	0.8	23.8
	1854	2.2	0.7	0.0	0.9	3.4	6.3	...	...	...	...	0.9	0.8	...
	1855	0.1	0.7	1.3	0.2	0.7	2.1	2.4	0.2	0.5	2.5	0.1	0.7	11.5
	1856	1.5	0.5	0.3	2.4	3.5	1.0	0.4	0.3	2.3	0.4	1.1	0.8	14.5
	Mean	1.9	1.0	0.6	1.4	2.4	3.5	1.6	1.8	2.1	2.1	1.5	0.8	20.7
Vesoul ..... 784 feet.	1852	1.2	0.7	0.0	0.0	0.6	4.5	0.3	3.5	2.4	1.2	4.1	2.2	20.7
	1853	1.4	1.7	0.3	3.7	5.4	2.8	3.3	1.6	4.1	2.4	0.7	0.1	27.5
	1854	1.2	0.2	0.0	0.9	1.7	3.2	1.2	0.7	0.0	2.5	2.8	1.5	15.9
	1855	0.6	4.5	2.3	0.7	2.3	2.1	3.1	1.2	3.5	3.9	1.0	0.3	25.5
	1856	1.8	0.9	0.9	2.2	7.4	2.5	0.5	2.1	4.4	1.7	1.3	1.2	26.9
	1857	1.4	0.2	0.6	2.6	2.8	2.4	0.6	2.4	2.9	2.1	0.9	0.5	19.4
	Mean	1.3	1.2	0.7	1.7	3.4	2.9	1.5	1.9	2.9	2.3	1.8	1.0	22.6
Gray ..... 768 feet.	1852	2.2	2.1	0.8	0.6	2.5	7.1	1.4	7.5	4.0	2.6	5.1	2.1	38.0
	1853	3.3	1.8	1.2	4.0	4.5	4.7	4.2	2.2	3.7	3.9	0.9	0.5	34.9
	1854	0.9	0.8	0.0	1.0	5.1	3.5	2.5	2.4	0.1	3.7	3.4	3.5	26.9
	1855	1.3	4.1	3.5	1.5	3.3	4.0	6.2	1.3	3.7	7.5	0.8	1.0	38.2
	1856	3.3	1.4	1.1	5.2	9.5	3.3	1.0	2.5	7.5	1.6	2.5	3.0	41.9
	1857	2.0	0.3	0.7	2.8	2.3	1.6	0.8	3.4	3.7	2.4	1.6	0.7	22.3
	Mean	2.2	1.7	1.2	2.5	4.5	4.0	2.7	3.2	3.8	3.6	2.4	1.8	33.7
Dijon ..... 869 feet.	1852	2.8	1.3	0.8	0.5	1.8	6.1	0.9	6.7	3.0	2.0	4.7	1.4	32.0
	1853	2.9	1.4	0.8	2.6	3.0	2.7	1.9	2.8	3.5	3.1	1.1	0.4	26.2
	1854	2.9	1.0	0.2	0.9	2.4	3.5	3.9	3.4	0.2	2.9	3.6	2.8	27.7
	1855	1.2	3.1	2.8	0.7	3.7	3.0	3.9	1.5	2.8	5.9	0.7	1.0	30.3
	1856	4.5	1.2	1.6	5.2	8.3	2.0	0.9	2.4	4.1	2.4	2.3	2.6	37.6
	1857	2.1	0.7	1.0	2.2	1.0	2.2	0.7	2.5	2.9	2.7	1.7	0.6	20.3
	Mean	2.7	1.5	1.2	2.0	3.3	3.2	2.0	3.2	2.8	3.2	2.4	1.5	29.0
Fort de Joux 3,284 feet.	1852	3.9	4.4	0.8	0.8	5.9	6.1	5.0	13.1	6.9	5.3	4.6	2.8	59.6
	1853	5.0	5.0	2.9	5.9	4.8	8.0	2.0	6.5	4.0	4.1	0.4	1.7	50.3
	1854	2.2	2.7	0.1	0.4	0.7	0.9	3.5	3.2	0.1	2.2	3.9	5.2	25.1
	1855	1.1	2.8	2.4	1.7	3.7	3.2	3.5	2.4	6.7	7.4	1.4	0.5	36.8
	1856	3.7	1.4	1.9	3.6	10.6	3.0	2.4	3.1	3.8	0.8	3.1	4.1	41.5
	1857	2.8	1.4	1.7	3.6	2.6	2.1	0.7	3.3	1.5	0.6	0.0	0.0	20.3
	Mean	3.1	2.9	1.6	2.7	4.7	3.9	2.9	5.2	3.8	3.4	2.2	2.4	38.8
Montbéliard 1,273 feet.	1852	2.2	3.7	0.7	0.6	2.4	3.9	1.9	5.1	4.3	1.4	3.2	0.8	30.2
	1853	2.0	1.2	1.3	2.5	3.5	2.7	1.6	1.7	1.7	2.1	0.6	0.4	21.3
	1854	0.5	0.9	0.0	0.4	1.1	0.9	1.3	0.2	0.0	0.6	1.2	3.9	11.0
	1855	0.7	1.6	0.8	0.4	0.6	0.6	1.2	0.7	1.2	2.9	1.4	1.1	13.0
	1856	2.2	0.2	0.8	1.9	7.1	1.5	0.7	1.0	1.9	0.9	2.3	1.8	22.4
	1857	0.9	0.1	0.7	2.0	1.4	1.7	0.2	1.6	1.0	1.8	0.3	0.2	11.9
	Mean	1.4	1.3	0.7	1.3	2.7	1.9	1.1	1.7	1.7	1.6	1.5	1.4	18.3
Besançon .... 1,191 feet.	1852	2.6	3.0	0.5	0.4	2.1	11.8	2.1	10.1	3.9	3.7	6.9	2.6	49.7
	1853	3.9	4.5	1.0	5.2	7.1	5.5	4.5	3.0	5.7	4.4	0.9	0.3	46.0
	1854	1.2	0.7	0.1	3.5	5.3	4.3	5.0	2.8	0.2	5.1	4.8	6.7	39.7
	1855	2.5	2.6	1.1	1.2	2.4	3.1	3.2	1.3	3.5	4.1	1.9	2.5	29.4
	1856	2.3	1.7	1.2	3.5	11.8	4.0	1.3	2.5	7.1	1.3	4.9	2.8	44.5
	1857	2.5	0.5	2.6	3.2	3.5	5.4	0.7	3.3	3.2	3.7	1.1	1.7	31.4
	Mean	2.5	2.2	1.1	2.8	5.4	5.7	2.7	3.8	3.9	3.7	3.4	2.7	40.0
Dôle ..... 751 feet.	1852	2.0	2.0	1.1	0.6	1.6	6.5	1.3	10.3	3.7	3.8	3.6	1.3	37.8
	1853	2.8	2.6	0.9	3.8	3.9	7.5	4.4	0.9	4.7	4.7	0.5	2.3	39.0
	1854	0.8	0.8	0.0	0.6	4.8	3.4	4.6	1.1	0.2	3.0	6.1	5.1	30.5
	1855	2.0	4.6	2.9	2 8	3.5	2.9	4.6	2.6	2.0	6.7	1.3	1.1	37.0
	1856	3.1	1.0	1.8	3.8	11.5	4.8	0.7	2.2	7.2	1.3	1.9	3.3	42.6
	1857	2.0	0.3	1.6	2.6	1.8	2.8	0.2	4.2	4.4	3.6	1 1	1.1	25.7
	Mean	2.1	1.9	1.4	2.4	4.5	4.7	2.6	3.5	3.7	3.8	2.4	2.4	35.4

RAINFALL OF FRANCE.

DETAILS OF MONTHLY FALL.

Period.		Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Châlon ..... 594 feet.	1852	1.8	1.2	0.6	0.6	0.8	5.3	1.3	5.9	2.5	1.6	3.3	1.7	26.6
	1853	2.4	1.3	0.9	2.4	2.1	3.1	2.0	1.6	3.4	4.1	1.2	1.0	25.5
	1854	0.9	0.6	0.1	0.4	3.5	2.4	2.2	2.0	0.0	3.8	3.7	2.8	22.4
	1855	1.1	1.8	1.3	0.1	2.0	1.7	3.5	1.1	2.6	5.0	1.3	0.5	22.0
	1856	1.0	1.4	1.3	4.1	8.3	1.4	0.3	2.3	6.5	0.5	2.0	3.7	32.8
	1857	2.9	0.6	0.1	1.5	0.8	0.9	1.6	2.9	2.2	5.5	1.4	0.7	21.1
	Mean	1.7	1.2	0.7	1.5	2.9	2.5	1.8	2.6	2.9	3.4	2.2	1.7	25.1
1806..... to 1848.....	Mean	1.9	1.8	1.7	1.8	1.9	1.9	2.9	2.1	1.8	2.0	2.3	2.0	23.4
	Days	10	10	10	10	9	9	10	10	9	10	12	12	121
	Mean Temp	33	38	44	51	60	65	68	68	62	54	46	40	52
Lons-le-Saulnier ..... 856 feet.	1852	3.8	3.4	1.2	0.9	5.5	16.1	1.5	14.8	4.9	5.9	5.1	1.2	64.3
	1853	7.5	4.9	3.2	...	8.5	6.3	...	...	...	...	...	0.8	...
	1854	1.3	0.7	0.0	1.3	11.0	7.7	6.1	4.6	0.0	5.2	4.5	4.4	46.8
	1855	3.0	5.1	3.5	2.5	2.9	3.3	2.4	1.3	2.9	4.1	1.9	0.4	33.3
	1856	2.2	1.4	1.0	3.9	15.5	4.5	1.0	1.5	8.6	1.2	3.0	3.0	46.8
	1857	1.5	0.4	0.6	5.4	2.6	2.2	0.1	4.2	3.5	4.7	0.9	1.1	27.2
	Mean	3.2	2.6	1.6	2.8	7.7	6.7	2.2	5.3	4.0	4.2	3.1	1.8	45.2
Bourg ..... 918 feet.	1852	2.0	2.4	1.8	0.9	1.3	9.0	2.0	13.2	3.9	4.8	5.0	0.9	47.2
	1853	2.6	1.0	0.9	3.5	6.1	4.8	2.6	2.0	3.9	4.9	1.2	0.8	34.3
	1854	1.1	1.3	0.0	1.1	5.9	5.9	5.3	2.5	0.1	4.1	5.0	5.5	37.8
	1855	1.0	6.5	2.0	1.3	3.9	4.9	2.8	1.3	1.9	7.0	1.8	2.4	36.8
	1856	3.9	1.4	2.0	6.5	11.6	4.6	0.9	2.9	5.7	2.0	2.7	5.1	49.3
	1857	1.2	1.0	1.2	3.6	3.0	3.7	0.5	4.4	2.7	5.0	1.3	1.0	28.6
	Mean	2.0	2.3	1.3	2.8	5.3	5.5	2.3	4.4	3.0	4.6	2.8	2.6	39.0
Lyons ..... (Fort Lamothe.) 598 feet.	1852	1.2	0.8	0.2	1.5	1.3	7.5	2.8	8.2	2.8	3.5	5.0	1.5	36.3
	1853	1.9	0.9	0.8	1.5	3.0	2.7	3.5	1.7	3.9	5.3	2.4	0.9	28.5
	1854	0.8	0.4	0.0	0.9	4.5	9.7	2.3	2.8	0.0	2.3	2.4	2.2	28.3
	1855	0.7	3.9	1.7	0.6	2.5	1.8	4.6	0.7	3.3	9.4	1.7	0.4	31.3
	1856	2.2	1.2	1.6	6.3	10.6	3.4	0.8	3.1	3.9	1.7	1.6	2.9	39.3
	1857	1.0	1.1	0.4	3.2	2.6	2.3	0.7	2.9	3.9	4.0	0.8	0.4	23.3
	Mean	1.3	1.4	0.9	2.3	4.1	4.6	2.4	3.2	3.0	4.4	2.3	1.4	31.3
Lyons ..... (Observatory.) 640 feet.	1852	0.3	0.5	0.2	1.3	1.7	7.6	3.1	7.6	2.1	3.3	4.5	1.1	33.3
	1853	1.4	0.6	0.8	1.0	2.5	2.3	3.6	1.5	3.7	5.1	2.0	1.0	25.5
	1854	0.9	0.4	0.1	0.7	4.4	8.1	2.4	2.5	0.0	2.0	2.4	2.2	26.1
	1855	0.6	3.9	1.7	0.6	2.5	1.8	3.7	1.3	2.4	7.1	1.6	1.4	28.6
	Mean	0.8	1.4	0.7	0.9	2.8	5.0	3.1	3.2	2.0	4.4	2.6	1.4	28.4
Lyons ..... Evaporation.	1852	0.9	0.8	1.1	2.6	3.8	3.0	4.6	2.0	2.0	1.2	0.9	0.6	23.5
	1853	0.7	0.2	0.3	1.1	1.6	2.7	4.0	3.3	1.9	1.1	0.6	0.0	17.5
	1854	0.2	0.2	1.7	2.9	2.6	2.9	3.7	3.0	2.2	1.6	0.6	0.6	22.2
	1855	0.0	0.4	1.0	2.4	2.3	3.3	3.3	3.1	1.7	1.1	0.4	0.6	19.5
	Mean	0.5	0.4	1.0	2.2	2.6	3.0	3.9	2.8	2.0	1.2	0.6	0.5	20.7
Besançon .... (Fort Bregille) 1,836 feet.	1846	1.0	0.5	2.4	2.4	2.7	0.8	2.0	3.5	2.1	4.1	3.0	1.2	25.7
	1847	1.0	0.3	0.8	3.6	2.1	2.1	2.8	4.5	1.5	3.5	0.7	0.6	23.5
	1848	0.3	1.9	2.1	2.8	1.6	3.6	3.2	3.2	1.6	3.4	1.5	0.6	25.8
	Mean	0.8	0.9	1.7	2.9	2.1	2.1	2.7	3.7	1.7	3.9	1.7	0.8	25.0
Distance 1,500 yards from Faculté des Sciences. 1,200 feet.	1846	3.6	2.0	4.0	4.7	3.7	1.5	2.8	3.9	2.3	5.9	4.4	4.7	43.5
	1847	1.6	2.4	2.0	6.6	2.8	3.2	3.6	6.6	3.2	5.5	1.4	2.0	40.9
	1848	0.9	5.5	5.8	6.6	2.2	4.8	4.2	5.5	2.6	4.3	4.3	1.7	48.4
	Mean	2.1	3.3	3.9	6.0	2.9	3.2	3.5	5.3	2.7	5.2	3.3	2.8	44.2
Rhone Basin Mean Fall of 18 Stations.	1845	5.7	1.0	3.6	2.8	3.1	3.0	2.0	4.2	5.2	2.8	4.0	5.9	43.3
	1846	3.7	0.8	4.2	4.9	4.0	3.9	2.1	3.7	5.4	6.7	3.5	3.2	46.1
	1847	2.3	2.9	1.2	7.2	2.1	3.0	2.6	3.7	1.2	4.2	1.9	1.9	34.2
	Mean	3.9	1.6	3.0	5.0	3.1	3.3	2.2	3.8	3.9	4.6	3.1	3.7	41.2

RAINFALL OF FRANCE AND ITS COLONIES.

DETAILS OF MONTHLY FALL.

Period.		Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Syam ..... (Jura Mounts.)	1845	...	...	...	...	...	...	...	7.8	8.6	4.5	5.5	13.4	...
	1846	8.0	2.5	7.7	7.6	4.3	6.0	3.6	7.3	4.6	7.5	6.3	7.9	73.3
	1847	3.1	5.6	3.3	11.7	3.2	5.0	5.0	5.7	4.0	3.7	1.6	3.2	55.1
	1848	1.7	7.7	9.3	10.1	4.1	6.7	5.5	5.9	3.8	6.3	6.2	2.6	69.9
	1849	9.6	2.8	2.6	6.7	8.6	6.9	3.9	1.7	4.8	10.9	7.7	5.5	71.7
Mean of 4 Years		5.6	4.7	5.7	9.0	5.1	6.2	4.5	5.1	4.3	7.1	5.4	4.8	67.5
Rodez	1846	3.9	0.5	3.9	5.5	5.5	4.5	1.3	...	...	...	2.1	4.3	...
	1847	1.8	3.9	2.3	4.7	1.5	2.7	1.0	2.8	1.1	2.4	2.6	1.7	28.5
	1848	1.0	0.6	5.0	1.8	5.8	6.3	0.8	0.8	2.8	2.4	2.6	4.7	40.6
	1849	5.5	0.8	8.8	6.7	5.2	2.4	1.0	0.5	1.2	3.0	5.7	1.2	42.0
	1850	2.4	0.5	0.2	4.3	5.9	0.2	2.4	5.5	3.2	9.1	4.6	5.3	43.6
	1851	1.2	1.8	3.1	3.3	2.6	0.1	2.8	1.0	1.9	1.8	1.4	0.6	21.6
	1852	1.6	1.8	1.6	3.7	3.0	5.9	4.7	4.8	1.3	4.0	15.7	19.5	67.6
Mean of 6 Years		2.2	2.6	3.5	4.1	4.0	2.9	2.1	2.6	1.9	3.8	5.4	5.5	40.6
Algiers	1838	3.3	4.7	2.9	2.5	0.2	0.0	0.0	0.1	1.7	2.7	1.8	14.1	34.0
	1839	3.6	4.1	2.7	5.1	0.9	0.0	0.0	0.1	0.4	3.3	6.9	1.3	28.4
	1840	4.8	3.4	5.0	3.0	0.6	0.7	0.0	0.0	1.9	0.9	2.5	8.9	31.7
	1841	6.2	4.3	0.6	3.2	0.7	0.3	0.0	0.0	0.0	3.0	5.5	11.4	35.2
	1842	7.4	1.6	2.8	3.9	3.5	0.0	0.0	1.7	2.0	3.9	7.0	1.6	35.4
	1843	3.6	6.0	3.5	1.7	0.4	0.2	0.0	0.0	0.3	1.5	11.0	1.9	30.1
	1844	6.5	7.3	3.4	6.7	3.5	0.0	0.1	0.4	1.6	3.2	0.9	7.6	41.2
	1845	7.9	15.6	4.3	1.7	4.4	0.7	0.0	0.0	1.3	1.0	0.8	3.5	41.2
	1846	2.8	1.4	1.7	1.7	2.9	0.3	0.0	0.3	3.6	7.5	7.1	11.9	41.2
	1847	4.2	9.8	4.1	5.3	0.4	0.8	0.0	0.4	0.1	1.8	17.6	6.9	51.4
	Mean	5.0	5.8	3.1	3.5	1.8	0.3	0.0	0.3	1.3	2.9	6.1	6.9	37.0
Oran ..... (Algeria.)	1852	3.0	2.1	1.5	2.7	3.2	0.0	0.0	0.0	0.6	0.4	2.2	0.5	16.2
	1853	4.4	11.5	1.5	0.4	1.3	0.7	0.0	0.0	0.0	0.1	5.5	2.6	28.0
Evaporation...	1853	2.5	2.0	3.4	4.8	6.2	7.9	8.3	7.2	5.5	5.2	2.7	1.8	57.5
Rainy Days...	1853	7	19	6	2	4	2	0	0	0	2	11	11	64
Mostaganem (Algeria.)	1853	2.5	6.8	2.2	0.2	1.1	1.1	0.0	0.0	0.0	0.4	4.2	3.5	22.0
	Days, 1853	9	18	8	1	5	3	0	0	0	3	10	10	67
Oviedo	1859	7.5	6.0	7.9	6.7	23.4	18.7	2.2	12.3	4.3	13.7	2.1	6.3	111.1
Havanna	1854	1.3	2.9	3.5	3.8	2.2	4.2	6.4	5.4	4.6	2.7	1.6	2.4	41.0
	1855	3.8	4.4	3.6	4.9	2.6	8.9	10.0	7.4	1.1	8.4	3.1	1.1	59.3
Rainy Days...	1854	9	4	4	13	11	13	9	9	10	9	5	10	106
	1855	11	4	3	4	4	17	17	13	3	8	7	5	96
Cayenne	1847	10.9	15.4	19.5	31.7	31.7	29.3	6.7	1.0	0.0	0.7	3.4	10.5	160.8
	1848	19.5	13.1	16.9	6.8	18.3	11.7	3.2	0.8	1.9	0.4	0.3	7.1	100.0
	1849	12.0	15.2	15.7	28.6	25.4	16.6	7.5	2.1	0.9	3.0	5.6	23.4	156.0
	1850	13.0	14.2	24.9	16.7	28.5	9.6	3.0	3.2	0.4	1.0	1.4	11.3	127.2
	1851	21.0	18.7	25.5	29.8	20.2	16.1	8.0	1.7	0.4	1.3	1.8	15.0	159.5
	1852	11.3	22.6	22.0	13.0	15.2	14.7	6.7	2.0	0.1	2.3	5.4	10.9	126.2
	Mean	14.6	16.5	20.8	21.1	23.2	16.3	5.9	1.8	0.6	1.5	3.0	13.0	138.3
Santa Fe de Bogota	1848	...	...	...	...	7.9	3.1	3.2	3.2	4.8	7.9	15.7	9.6	...
	1849	5.5	3.3	3.9	12.7	8.5	4.8	4.0	6.0	2.0	10.4	7.9	5.4	74.8
	1850	5.4	5.1	3.1	6.3	5.9	...	...	...	...	...	...	...	...
	Days	15	10	13	19	19	15	17	19	12	20	17	14	190
St. Benoit ... (Réunion.)	1842	...	...	...	...	...	...	4.0	6.5	4.1	3.1	1.3	12.3	...
	1843	22.5	10.6	10.6	41.2	5.2	0.7	9.3	4.8	11.4	6.2	7.5	12.6	142.6
	1844	40.2	30.9	30.6	16.5	6.7	7.2	8.9	4.0	3.8	2.7	4.2	49.0	204.7
	1845	33.0	21.0	14.0	19.1	28.9	7.3	31.1	7.3	6.1	2.3	3.5	12.2	185.8
	1846	17.8	25.5	10.0	16.7	12.7	2.0	...	...	...	...	...	...	...
	Mean	28.4	22.0	16.3	23.4	13.4	4.5	13.3	5.6	6.4	3.6	4.1	21.5	162.3

RAINFALL OF NORTH AMERICA.

TABLE OF MEAN ANNUAL FALL OF RAIN,

AND TEMPERATURE OF VARIOUS STATIONS,

Showing their latitude, longitude, and height above the sea level, with the number of years on which the mean has been taken.

Place.	Province.	Lat. N.	Long. W.	Height.	Temp.	Rain.	No. of Years.	Remarks.
		deg.m	deg.m	feet.	Fah.	inches	yrs.	
Hancock Barracks	Maine	46.07	67.49	620	40.5	36.97	9	St. John's R.
Fort Sullivan	,,	44.54	66.58	70	43.0	39.39	8	,,
,, Preble	,,	43.39	70.20	20	45.2	45.25	8	Atlantic.
,, Constitution	N. Hampshire	43.04	70.49	40	45.8	35.57	13	,,
Watertown Arsenal	Massachusetts	41.21	71.09	100	47.3	42.07	7	
Fort Trumbull	Connecticut	41.21	72.06	23	49.6	45.69	3	Long I. Sound
,, Hamilton	New York	40.37	74.02	25	51.5	43.65	16	Atlantic.
,, Columbus	,,	40.42	74.01	23	51.7	42.23	18	Bay.
St. Martin (Montreal)	Canada E.	45.32	73.36	118	43.0	44.46	3	
Plattsburgh	New York	44.41	73.25	186	44.0	33.39	9	L. Champlain.
Toronto	Canada W	43.39	70.21	342	44.2	31.50	8	L. Ontario.
Fort Ontario	New York	43.20	76.40	250	46.4	30.88	8	,,
,, Niagara	,,	43.18	79.08	250	47.9	31.77	10	,,
Buffalo	,,	42.53	78.58	600	46.2	38.80	3	Lake Erie.
Alleghany Arsenal	Pennsylvania	40.32	80.02	704	50.8	34.96	18	
Carlisle Barracks	,,	40.12	77.14	500	51.1	34.01	6	
Fort Mifflin	,,	39.53	75.13	20	53.8	45.27	9	Delaware Bay.
,, McHenry	Maryland	39.17	76.35	36	54.3	42.00	18	Chesapeake B.
,, Severn	,,	38.58	76.27	20	55.4	48.61	3	,,
Washington	,,	38.53	77.02	90	56.1	41.20	5	
Fort Monroe	Virginia	37.00	76.18	8	58.9	50.89	13	,,
,, Moultrie	S. Carolina	32.45	79.51	25	66.6	44.92	12	Atlantic.
Oglethorpe Barracks	Georgia	32.05	81.07	40	67.4	53.33	5	Marshes.
Fort Shannon	Florida	29.34	81.48	25	69.6	48.68	3	
Key West	,,	24.32	81.48	10	76.5	47.65	9	G. of Mexico.
Fort Brooke	,,	28.00	82.28	20	71.9	55.47	14	,,
Cedar Keys	,,	29.07	83.03	35	69.6	48.50	3	,,
Fort Barrancas	,,	30.18	87.27	20	68.7	56.98	9	,,
Mount Vern. Arsenal	Alabama	31.12	88.02	200	65.8	63.50	10	Mobile River.
New Orleans	Louisiana	29.57	90.00	10	69.8	50.90	15	Mississippi.
Baton Rouge	,,	30.26	91.18	41	68.1	62.10	12	,,
Fort Jesup	,,	31.33	93.32	80	66.3	45.85	9	Inland.
,, Towson	Ind. Terr.	34.00	95.33	300	61.7	51.08	16	,,
,, Washita	,,	34.14	96.38	645	62.2	41.66	11	,,
,, Gibson	,,	35.47	95.10	560	60.8	36.46	18	,,
,, Smith	Arkansas	35.25	94.29	460	60.0	42.10	16	,,
,, Scott	Missouri	37.45	94.35	1000	54.5	42.12	10	,,
Jefferson Barracks	,,	38.28	90.15	472	55.4	37.83	13	Mississippi.
St. Louis Arsenal	,,	38.40	90.05	450	54.5	41.95	17	,,
Detroit	Michigan	42.20	82.58	580	47.2	30.07	12	
Fort Mackinac	,,	45.51	84.33	728	40.6	23.87	10	Lake Huron.
,, Brady	Illinois	46.30	84.43	600	40.4	31.35	16	Lake Superior
,, Howard	Wisconsin	44.30	88.05	620	44.5	34.65	7	Marshy.
,, Winnebago	,,	43.31	89.28	770	44.8	27.49	9	,,
,, Crawford	,,	43.05	91.00	642	47.6	31.40	9	Mississippi.
,, Snelling	Minnesota	44.53	93.10	820	44.5	25.43	18	,,
,, Ripley	,,	46.19	94.19	1130	39.3	29.48	5	,,
,, Leavenworth	Kansas	39.21	94.44	896	52.8	30.29	19	
,, Kearney	Nebraska	40.38	98.57	2360	47.7	27.98	5	
,, Laramie	,,	42.12	104.47	4519	50.1	28.15	3	
,, Arbuckle	Ind Terr.	34.27	97.09	1000	60.8	30.57	4	
,, Chadbourne	Texas	31.38	100.40	2120	62.4	31.88	3	
,, Brown	,,	25.54	97.26	50	73.7	33.65	5	
Ringgold Barracks	,,	26.23	99.02	200	74.2	20.95	5	
Fort Clark	,,	29.17	100.25	1000	67.1	21.80	3	

RAINFALL OF NORTH AMERICA.

TABLE OF MEAN ANNUAL FALL OF RAIN,

AND TEMPERATURE OF VARIOUS STATIONS,

Showing their latitude, longitude, and height above the sea level, with the number of years on which the mean has been taken.—(See Tables of Details.)

Place.	Province.	Lat. N.	Long. W.	Height.	Temp.	Rain.	No. of Years.	Remarks.
		deg.m	deg.m	feet.	Fah.	inchs.	yrs.	
Fort Fillmore	New Mexico	32. 13	106. 42	3,937	63. 9	9. 23	3	
,, Webster	,,	32. 47	108. 04	6,350	54. 8	8. 79	1	In wide valleys between high & precipitous mountains.
,, Thorn	,,	32. 38	107. 10	4,500	58. 4	14. 60	1	
,, Conrad	,,	33. 34	107. 09	4,576	59. 4	6. 76	3	
Albuquerque	,,	35. 06	106. 38	5,032	56. 3	9. 42	2	
Fort Union	,,	35. 54	104. 57	6,670	49. 1	19. 24	5	
,, Defiance	,,	35. 44	109. 15	7,200	46. 9	16 64	3	
,, Yuma	California	32. 43	114. 36	120	73. 6	3. 24	3	Sea exposure?
San Diego	,,	32. 42	117. 14	150	62. 0	10. 43	5	,,
Fort Miller	,,	37. 00	119. 40	402	66. 0	24. 51	3	Mntains. around
San Francisco	,,	37. 48	122. 26	150	54. 9	23. 59	3	,,
Fort Reading	,,	40. 30	122. 05	674	62. 1	29. 02	3	
,, Vancouver	Oregon	45. 40	122. 30	50	52. 6	45. 50	5	Sea exposure.
,, Dalles	,,	45. 36	120. 55	350	52. 8	14. 32	4	,,
,, Steilacoom	Washington	47. 10	122. 25	300	50. 8	51. 75	5	,,
Quebec	Canada.	46. 48	71. 13	230	41. 8	67. 51	3	R. St. Lwrence.
Kingston	,,	44. 13	76. 30	294	44. 6	27. 95	3	
Halifax	,,	44. 39	63. 36	169	44. 8	55. 31	1	Atlantic, 1853–4.
St. John's	Newfndland	47. 35	52. 42	124	...	55. 05	1	,,

RAINFALL OF RUSSIAN EMPIRE.

(See Tables of Details.)

Place.	Lat. N.	Long. E.	Height.	Temp.	Rain.	No. of Years.	Remarks.
	deg.m.	deg.m.	feet	Fah.	inchs.	yrs.	
Mitau	56. 39	23. 43	13	...	18. 29	4	Baltic Sea.
Riga	56. 57	24. 06	114	...	16. 58	4	,,
Revel	59. 27	24. 46	80	...	20. 52	4	Gulf of Finland.
Helsingfors	60. 10	24. 57	50	38. 7	17. 66	4	,,
Cronstadt	59. 59	29. 46	20	38. 7	14. 70	4	,,
St. Petersburg	59. 56	29. 18	10	39. 6	14. 76	9	
Lougan	48. 35	39. 20	330	44. 2	13. 41	9	
Archangel	64. 32	40. 34	30	33. 5	14. 52	1	White Sea.
Kutais	42. 20	42. 40	...	...	61. 38	3	Black Sea.
Alagir	43. 05	44. 19	1,720	47. 0	35. 90	3	Inland.
Tiflis	41. 42	44. 50	1,500	54. 6	16. 86	6	,,
Orenbourg	51. 46	55. 06	280	35. 1	15. 43	3	,,
Zlatoosk	55. 10	59. 40	1,200	...	20. 22	8	,,
Nije-Taginlsk	57. 54	59. 53	13	...	8. 83	1	,,
Boboslovsk	59. 45	60. 02	600	30. 4	13. 32	4	,,
Catherinebourg	56. 49	60. 35	800	32. 9	12. 28	6	,,
Tobolsk	58. 12	68. 16	355	...	22. 98	2	,,
Barnaoul	53. 20	83. 57	400	31. 4	9. 50	8	,,
Bacou	40. 22	49. 50	53	56. 0	12. 14	6	Caspian Sea.
Aralikh	46. 04	47. 65	...	...	6. 08	4	,,
Lencoran	38. 44	48. 53	65	57. 0	51. 15	1	,,
Redout-Kaleh	42. 30	41. 20	...	58. 0	62. 94	6	Black Sea.
Alexandropol	40. 47	43. 47	4,800	41. 0	15. 69	3	Inland.
Pekin	39. 54	116. 27	...	...	24. 93	6	
Sitka	57. 03	135. 18	...	54. 4	85. 79	7	North Pacific.
Nertchinsk	51. 19	119. 36	2,230	24. 87	15. 03	9	Inland.

RAINFALL OF RUSSIAN EMPIRE.

DETAILS OF MONTHLY FALL

At some of the principal Stations referred to in the table of Annual Rainfall.

Period.		Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Mitau.	1855	1.36	0.02	1.37	0.24	3.20	1.82	2.01	2.93	3.92	2.12	0.75	0.93	20.67
	1856	1.67	0 70	0.46	0.69	1.81	2.02	4.94	2.68	1.45	1.02	2.53	1.54	21.51
	1857	1.16	0.11	0.56	1.76	2.77	0.62	2.57	1.68	2.27	0.39	0.74	1.53	16.16
	1858	1.52	0.24	1.00	0.85	0.58	0.82	1.74		0.71	2.39	1.19		
	Mean	1.43	0.27	0.85	0.88	2.09	1.32	2.82	2.43	2.09	1.48	1.30	1.33	18.29
Riga.	1855	0.19	0.41	0.41	0.55	2.13	2.07	1.39	4.64	5.00	1.68	1.03	0.98	20.48
	1856	0.69	0.96	0.50	2.52	2.33	3.62	1.28	0.97	1.78	0.89	2.04	1.06	18.04
	1857	1.58	0.13	1.51	1.23	1.38	1.08			1.76	0.48	0.44	1.58	
	1858	1.37	0.52	2.23	1.55	1.01	0.45	0.81	0.48	0.42	1.00	1.71		
	Mean	0.96	0.50	1.19	1.46	1.71	1.81	1.16	2.03	2.24	1.01	1.30	1.21	16.58
Revel.	1855	1.07	1.20	0.37	0.46	2.42	0.30	2.97	3.39	1.74	2.64	1.82	1.01	19.39
	1856	0.58	1.28	0.39	0.48	2.46	2.24	1.65	2.41	1.08	1.77	1.34		15.68
	1857	0.64	0.19	0.09	0.33	0.67	0.43	0.66	0.37	0.87	0.55	0.37		
	1858	2.29	2.67	0.85	1.27	5.55	2.97	5.28	6.17	3.69	4.96	3.53	1.01	40.24
	Mean	1.15	1.33	0.42	0.64	2.78	1.48	2.64	3.09	1.84	2.48	1.76	1.01	20.52
Helsing-fors	1855	1.09	0.45	1.43	0.63	1.87	0.13	0.09	2.54	1.17	2.74	1.55	0.87	14.56
	1856	2.25	1.28	0.66	1.83	2.11	1.68	1.56	3.23	2.87	1.40	1.74		
	1857			0.98	1.59	0.80	1.35	2.58	0.49	1.27	2.09	0.96	1.41	
	1858	0.89	0.36	2.38	2.79	0.83	0.56	1.57	1.54	1.49	3.03	2.18		
	Mean	1.41	0.69	1.36	1.71	1.40	0.93	1.45	1.95	1.70	2.31	1.61	1.14	17.66
Cron-stadt.	1855	0.48	0.29	0.26	1.03	0.69	1.36	0.16	2.84	1.37	1.88	1.18	0.57	12.11
	1856	1.61	0.70	0.39	1.87	1.07	2.84	2.31	7.13	0.99	0.70	1.05		
	1857	0.87	0.38	0.36	1.05	1.32	1.09	1.35	2.61	0.82	0.97	0.42	0.64	11.88
	1858	0.37	0.42	0.95	0.64	1.70	0.45	1.98	0.44	1.52	2.80	1.74		
	Mean	0.82	0.45	0.49	1.15	1.19	1.44	1.45	3.25	1.17	1.59	1.10	0.60	14.70
St. Petersburg.	1850	0.66	0.96	1.64	0.06	0.31	1.67	2.13	2.78	2.45	3.52	2.25	1.70	20.13
	1851	0.80	0.87	1.00	0.95	4.42	2.47	1.40	1.90	0.07	1.16	1.38	2.36	18.78
	1852	1.50	1.20	1.69	0.34	0.60	2.12	1.80	1.70	1.50	2.07	0.97	0.17	15.31
	1853	0.40	0.78	0.92	0.61	0.17	0.20	1.34	1.84	1.33	1.41	0.41	1.00	10.41
	1854	0.18	1.16	0.32	0.53	2.20	1.45	0.97	0.76	2.56	0.86	0.85	1.05	12.89
	1855	0.45	0.70	0.34	1.07	2.30	2.20	0.29	2.02	2.55	1.34	1.43	0.47	15.16
	1856	1.00	1.15	0.71	2.09	1.68	2.27	1.23	1.84	1.12	0.87	0.66	0.45	15.07
	1857	1.13	1.44	0.44	0.60	0.83	0.70	2.15	2.26	0.42	0.84	1.54	0.65	13.00
	1858	0.35	0.69	1.07	0.76	1.28	0.31	2.48	0.16	0.91	1.89	1.09		
	Mean	0.72	0.99	0.90	0.78	1.53	1.48	1.53	1.69	1.43	1.55	1.18	0.98	14.76
Longan.	1850	0.31	0.35	1.14	1.73	1.09	0.98	0.89	1.80	0.08	0.41	3.02	1.02	12.82
	1851	0.45	0.75	0.92	1.06	1.91	1.74	0.99	1.26	1.36	0.43	0.59	0.37	11.83
	1852	1.66	0.53	0.34	1.17	1.92	1.41	0.98	3.02	0.48	0.32	1.90	0.71	14.44
	1853	1.33	1.52	0.62	0.32	0.92	2.49	0.43	1.28	1.09	0.47	1.30	0.44	12.21
	1854	0.97	0.71	0.54	0.76	1.81	3.10	3.31	3.52	2.02	0.20	1.83	1.62	20.39
	1855	1.37	1.13	0.55	0.33	0.55	1.21	0.58	0.17	1.53	0.53	0.31	1.31	9.57
	1856	1.18	0.88	0.40	0.75	1.40	0.96	0.20	0.90	1.11	0.26	1.17	0.58	9.79
	1857	1.27	0.03	0.52	0.62	0.37	1.10	5.29	4.44	1.35	0.05	0.46	0.74	16.25
	1858	0.60	0.17	4.57	4.07	1.79	2.60	1.23	1.19	1.03	0.28	3.09		
	Mean	1.02	0.67	1.07	1.20	1.31	1.73	1.54	1.95	1.12	0.33	1.49	0.85	13.41
Arch-angel	1856	1.35	1.60	1.21	1.04	0.92	2.12	0.80	0.94	1.09	1.40	1.15	0.90	14.52
Kutais.	1850	6.60	8.16	8.20	2.53	1.30	8.71	3.78	4.69	5.88	2.69	4.62	11.42	68.58
	1851	2.68	6.83	9.87	1.76	1.16	7.34	4.30	2.58	0.64	3.53	0.86	4.97	46.52
	1852	9.01	3.10	3.42	6.04	3.18	3.34	7.26	4.99	4.08	6.66	9.29	8.66	69.03
	Mean	5.13	4.89	6.45	3.07	2.30	5.79	5.43	3.78	3.53	4.29	4.92	5.02	61.38
Alagir.	1855	1.52	0.67	0.70	6.56	4.93	4.03	4.94	3.94	3.11	1.63	0.35	0.85	33.23
	1856	0.31	1.68	1.12	2.40	6.02							1.96	
	1857	0.29	1.21	1.24	2.63	10.24	5.15	6.36	5.97	5.59	1.50	1.36	0.00	
	Mean	0.71	1.19	1.02	3.86	7.06	4.29	6.65	4.95	2.35	1.56	0.86	1.40	35.90

RAINFALL OF RUSSIAN EMPIRE.

DETAILS OF MONTHLY FALL

At some of the principal Stations referred to in the table of Annual Rainfall.

Period.		Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Tiflis.	1852	0.55	1.06	1.99	1.28	2.05	4.14	3.08	0.99	1.61	0.14	0.53	0.60	18.02
	1853	0.53	0.46	0.74	2.53	2.28	3.59	2.78	0.77	1.40	1.08	0.69	1.53	18.38
	1854	0.62	0.65	1.51	1.63	6.02	4.17	1.62	1.61	1.83	1.05	0.43	0.80	21.94
	1855	0.51	0.10	0.52	1.60	2.09	1.61	2.97	0.69	1.38	1.25	1.19	2.09	16.00
	1856	0.03	0.54	0.95	2.32	2.17	1.29	0.77	0.33	0.86	0.74	0.79	0.45	11.24
	1857	1.13	1.44	0.96	0.50	1.51	1.62	1.30	0.40	3.82	0.80	1.11	0.99	15.58
	1858	0.33	1.13	0.41	3.10	1.65	0.43	5.29	2.54	2.86	1.81	1.41	...	...
	Mean	0.53	0.77	1.01	1.85	2.54	2.41	2.54	1.05	1.97	0.98	0.88	1.08	16.86
Orenburg.	1855	0.85	1.86	0.95	0.14	0.57	1.25	2.05	0.76	2.05	0.69	0.64	1.20	13.01
	1856	2.04	4.80	3.29	1.86	1.45	1.66	1.60	0.83	1.36	1.97	1.36	1.40	23.62
	1857	0.53	0.68	0.28	0.50	0.61	0.67	2.11	0.83	0.77	0.89	0.57	1.23	9.67
	1858	0.98	2.81	0.93	0.92	1.25	4.62	1.67	0.87	1.23	0.98	2.81	...	...
	Mean	1.10	2.54	1.36	0.85	0.97	2.05	1.86	0.82	1.35	1.13	1.34	1.28	15.43
Zlatoouste.	1850	0.18	0.71	0.79	0.16	2.69	1.44	3.00	1.81	0.28	0.99	1.16	0.92	14.13
	1851	0.73	0.64	0.28	1.47	1.92	1.84	6.62	4.97	0.05	2.12	2.01	1.78	24.43
	1852	0.28	0.23	0.26	0.63	0.73	2.23	6.77	2.24	2.31	2.65	1.27	0.90	20.50
	1853	1.37	0.03	0.51	0.87	3.55	3.15	5.66	5.64	6.20	3.29	0.69	2.18	33.14
	1854	0.25	0.98	0.84	0.62	1.44	1.52	3.00	1.69	1.88	1.27	0.39	0.52	14.40
	1855	0.18	0.58	0.61	0.44	2.14	3.10	4.60	3.16	3.07	1.26	0.68	0.77	20.59
	1856	0.60	0.41	0.94	3.03	0.95	3.49	2.08	2.29	1.40	1.78	0.43	0.61	18.01
	1857	0.14	0.85	0.95	0.80	2.10	1.84	3.27	2.57	1.33	1.19	0.95	0.58	16.57
	1858	0.16	0.26	0.15	0.55	0.57	6.28	5.49	3.94	4.04	2.09	2.10	...	...
	Mean	0.43	0.52	0.59	0.95	1.79	2.76	4.50	3.15	2.28	1.85	1.08	1.03	20.22
Nije-Tagilsk	1856	0.26	0.66	0.34	0.33	1.13	0.80	1.13	2.08	1.17	0.65	0.28	...	8.83
Bogoslovsk.	1854	0.86	1.16	0.52	1.84	1.53	2.38	1.94	1.89	1.17	0.16	0.63	0.34	14.42
	1855	0.27	1.26	0.57	0.51	0.89	1.18	2.61	1.06	0.74	1.00	1.06	0.88	12.03
	1856	0.62	0.96	1.68	1.05	3.20	1.05	0.56	4.39	1.55	1.08	0.66	1.72	18.52
	1857	0.31	0.61	1.56	0.35	0.59	1.92	2.25	2.24	2.86	1.80	0.25	1.56	16.30
	1858	0.05	0.66	0.70	0.99	0.61	2.96	0.78	2.94	2.39	1.14	0.76	...	...
	Mean	0.42	0.93	1.01	0.95	1.36	1.90	1.63	2.51	1.74	1.03	0.67	1.12	15.32
Catherineburg.	1850	0.08	0.21	0.20	0.19	5.08	3.86	7.20	1.78	0.42	0.19	0.40	0.57	20.18
	1851	0.05	0.09	0.33	0.21	1.99	4.09	5.09	1.05	...	1.49	0.63	0.53	...
	1852	0.04	0.04	0.02	0.34	0.16	4.07	4.46	3.86	1.12	0.34	0.21	0.51	15.17
	1853	0.35	0.10	0.34	0.21	0.37	0.83	1.83	0.64	4.05	0.73	0.31	...	...
	1854	0.23	0.28	0.14	0.01	2.07	3.03	1.88	1.52	1.58	0.55	0.27	0.26	11.82
	1855	0.09	0.54	0.36	0.10	0.28	3.89	1.29	1.98	1.82	0.11	0.07	0.16	10.69
	1856	1.12	0.33	0.18	0.51	1.18	0.63	2.22	1.09	0.93	0.41	0.11	0.18	8.89
	1857	0.36	0.06	0.22	0.39	0.73	1.07	1.18	1.26	0.63	0.33	0.33	0.38	6.94
	1858	0.02	0.12	0.01	0.24	1.31	4.10	3.40	3.48	2.25	0.48	0.25	...	...
	Mean	0.26	0.20	0.20	0.24	1.46	2.84	3.17	1.85	1.60	0.51	0.29	0.37	12.28
Tobolsk.	1856	1.13	0.63	1.25	0.76	1.30	2.96	6.63	3.59	2.38	2.90	1.69	2.38	27.60
	1857	0.81	0.71	0.90	0.20	2.16	3.52	3.76	2.06	0.90	1.28	0.81	1.25	18.36
	1858	0.50	0.68	0.19	1.20	1.09	4.86	2.63	4.79	1.67	1.85	2.78	...	...
	Mean	0.81	0.67	0.78	0.72	1.52	3.78	4.34	3.48	1.65	2.01	1.76	1.81	22.98
Barnaoul.	1850	0.28	0.53	0.12	0.05	0.22	0.42	1.04	1.76	0.05	0.05	0.71	0.80	5.92
	1851	0.85	0.31	0.47	0.93	2.31	2.22	1.47	2.79	1.23	1.09	1.33	0.16	15.14
	1852	0.30	0.70	0.13	0.11	1.15	0.57	0.60	2.11	0.43	0.48	0.77	0.47	7.82
	1853	0.18	0.08	0.40	0.10	0.92	0.81	2.85	0.70	0.27	0.60	0.96	0.75	8.62
	1854	0.66	0.06	0.53	0.55	0.99	1.44	1.09	0.73	0.65	0.64	0.95	1.81	10.10
	1855	0.11	0.16	4.77	0.01	0.36	0.68	1.14	0.28	0.13	0.20	1.13	0.66	9.63
	1856	0.33	0.26	0.19	0.29	2.00	1.93	1.85	1.04	0.91	0.98	0.79	1.36	11.93
	1857	0.03	0.37	0.37	0.27	0.58	0.71	1.79	0.40	0.75	0.59	0.91	0.55	7.32
	1858	0.51	0.36	1.07	0.06	0.70	1.32	0.87	1.25	0.41	0.35	0.54	...	...
	Mean	0.36	0.31	0.89	0.26	1.03	1.12	1.41	1.23	0.45	0.55	0.90	0.82	9.50

RAINFALL OF RUSSIAN EMPIRE.

DETAILS OF MONTHLY FALL

At some of the principal Stations referred to in the table of Annual Rainfall.

Period.		Jan.	Feb.	Mar	Apr.	May.	Jne.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Totl.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Bacou.	1853	0.70	0.99	1.16	1.27	0.14	1.09	0.55	0.20	3.44	3.33	3.93	2.54	19.34
	1854	1.10	1.65	1.23	0.94	0.73	0.56	0.01	0.12	0.08	0.04	0.85	0.64	7.95
	1855	3.09	0.25	0.14	0.56	3.53	0.44	0.03	0.76	1.12	0.73	0.19	1.34	12.18
	1856	0.44	0.62	1.29	2.42	0.23	0.15	0.02	0.59	0.17	1.16	0.74	0.05	7.88
	1857	0.97	1.40	0.51	0.47	1.99	0.31	...	...	...	...	...	1.01	...
	1858	0.20	0.52	0.39	0.12	0.91	0.07	0.20	6.42	1.39	0.44	1.46	1.12	13.24
	Mean	1.08	0.90	0.79	0.96	1.26	0.44	0.16	1.62	1.24	1.14	1.43	1.12	12.14
Aralikh.	1849	...	...	0.14	0.55	0.92	0.95	...	...	0.68	0.13	...	0.53	...
	1850	0.36	0.27	0.15	2.24	1.78	1.23	0.12	0.60	0.30	0.95	0.55	1.06	9.61
	1851	0.56	0.32	0.08	0.36	0.49	0.62	0.00	0.12	0.00	0.10	0.10	0.43	3.18
	1852	0.20	0.55	0.68	1.04	0.58	1.47	0.05	0.05	0.20	0.71	0.08	0.62	6.19
	1853	0.28	0.29	0.66	0.77	1.94	0.51	0.05	0.10	...	...	...	...	...
	Mean	0.35	0.36	0.34	0.99	1.14	0.96	0.06	0.20	0.29	0.47	0.25	0.66	6.77
Lencoran	1855	8.48	4.60	2.16	5.40	1.54	2.74	2.38	4.17	4.12	5.19	6.42	3.95	51.15
	1856	3.22	5.88	7.01	4.41	1.66	0.31	2.10	1.79	6.69	15.89	8.16	...	...
Bedout-Kalé.	1848	...	...	...	0.56	3.45	7.30	1.68	7.81	4.08	3.75	5.05	5.61	...
	1849	2.13	3.75	5.37	0.84	3.16	5.30	13.43	3.78	11.14	1.70	1.21	3.46	55.28
	1850	7.49	5.82	6.90	1.74	0.51	11.54	5.04	7.68	11.70	4.19	8.07	7.31	78.01
	1851	3.28	6 33	5.19	1.72	0.43	18.32	5.64	18.14	3.59	2.34	0.66	7.39	79.05
	1852	6.50	3.99	5.17	3.95	2.43	7.05	9.08	4.71	3.49	1.16	5.59	2.64	55.75
	1853	2.37	0.98	6.09	1.38	3.19	7.10	10.99	3.81	7.04	3.40	3.43	4.66	52.51
	1854	4.31	8.89	4.54	...	...	...	...	...	...	...	...	...	...
	Mean	4.35	4.96	5.21	1.70	2.19	9.44	7.64	7.67	6.84	3.76	4.00	5.18	62.94
Alexandropol.	1855	0.82	0.96	0.10	2.19	2.02	3.46	2.25	0.51	1.01	1.18	1.40	1.46	17.36
	1856	0.43	0.59	1.10	1.14	2.42	1.47	0.53	0.14	0.86	1.07	0.62	0.18	10.55
	1857	1.63	0.61	1.98	0.81	4.19	1.32	3.10	1.27	0.34	0.64	2.44	...	...
	Mean	0.96	0.72	1.06	1.38	2.88	2.08	1.96	0.64	0.74	0.96	1.49	0.82	15.69
Pekin.	1850	0.02	0.51	0.14	0.58	4.22	6.00	3.69	6.50	0.21	0.12	0.77	0.78	23.54
	1851	0.12	0.00	0.74	0.68	1.82	0.97	11.23	3.46	2.69	0.56	0.06	0.10	22.43
	1852	0.00	0.71	0.32	0.17	1.31	1.83	10.64	5.69	1.64	0.40	0.46	0.66	23.83
	1853	0.20	0.52	0.57	1.12	0.38	5.62	7.60	10.76	11.48	0.19	0.28	0.09	38.81
	1854	1.16	0.32	0.07	0.11	0.81	0.55	2.39	4.25	3.46	0.01	0.02	...	13.15
	1855	...	...	0.09	0.06	0.64	1.81	7.00	10.05	5.75	...	0.95	...	...
	Mean	0.30	0.41	0.32	0.45	1.53	2.80	7.09	6.78	4.21	0.21	0.42	0.41	24.93
Sitka.	1850	3.52	11.31	2.10	6.65	3.71	9.80	3.14	10.31	15.23	14.06	10.07	5.89	95.79
	1851	8.09	7.20	5.62	4.24	1.64	5.34	4.67	2.69	2.43	13.78	8.39	8.37	72.46
	1852	11.38	7.85	4.54	3.16	4.72	2.63	1.89	8.54	12.62	12.50	5.61	1.72	77.16
	1853	15.03	4.15	3.61	3.10	5.08	6.16	4.12	7.18	6.73	19.53	0.45	15.88	91.02
	1854	2.50	6.29	10.09	3.40	7.82	4.48	4.90	3.97	8.42	11.53	14.73	9.06	87.17
	1855	4.44	12.57	6.60	6.70	2.79	5.08	8.11	3.07	12.73	11.14	7.78	6.50	87.51
	1857	3.12	2.03	2.07	6.56	4.60	5.80	10.89	6.44	8.08	9.86	12.70	17.27	89.42
	Mean	6.87	7.34	4.95	4.83	4.34	5.61	5.39	6.03	9.46	13.20	8.53	9.24	85.79
Nertchinsk.	1850	0.10	0.11	0.54	0.67	0.28	3.53	2.67	3.76	1.31	0.94	0.10	0.26	14.27
	1851	0.02	0.01	0.13	0.65	0.89	0.64	3.81	3.87	1.99	1.15	0.04	0.11	13.31
	1852	0.00	0.12	0.97	0.25	2.38	4.36	3.52	1.28	2.28	1.13	0.68	0.13	17.10
	1853	0.00	0.07	0.33	1.56	0.57	2.16	0.92	3.71	1.36	1.27	0.22	0.15	12.32
	1854	0.52	0.03	0.04	3.00	1.47	1.48	2.51	11.67	2.46	...	0.13	0.14	23.45
	1855	0.02	0.14	0.41	0.54	2.04	0.82	1.92	1.88	0.09	0.35	0.05	0.18	8.44
	1856	0.07	0.02	0.18	1.06	2.76	4.04	5.53	3.34	4.24	0.52	0.13	0.17	22.06
	1857	0.02	0.03	0.08	0.83	0.79	1.98	4.37	1.58	1.35	0.96	0.66	0.02	12.67
	1858	0.06	0.19	0.00	1.03	0.98	1.56	1.58	3.48	1.06	0.46	0.49	0.00	10.89
	Mean	0.09	0.08	0.30	1.06	1.35	2.28	2.98	3.84	1.79	0.85	0.28	0.13	15.03

RAINFALL OF NORTH AMERICA.

DETAILS OF MONTHLY FALL

At some of the principal Stations referred to in the table of Annual Rainfall.

NOTE.—The Means are those of the number of years named in the table of Annual Rainfall, not of the more limited years, of which the detail is here given.

Period.		Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Fort Sullivan	1850	3.83	2.32	2.80	1.50	5.10	6.10	7.10	2.58	4.80	3.24	3.00	4.80	47.17
	1851	2.81	4.10	4.60	3.30	2.80	1.40	3.35	0.90	3.30	4.50	3.00	2.60	36.06
	1852	4.30	3.60	2.90	4.10	0.30	2.20	4.00	4.80	3.40	3.50	4.20	2.50	39.80
	Mean	3.17	3.18	3.16	2.80	2.92	2.15	4.28	3.62	3.17	3.29	3.39	4.26	39.39
Fort Preble.	1850	4.85	3.20	2.70	4.60	1.55	4.80	2.90	3.35	5.95	3.45	2.80	4.50	59.00
	1851	3.55	5.80	2.45	7.35	3.90	3.87	3.65	2.22	4.41	8.43	6.58	2.89	46.10
	1852	4.79	2.56	3.59	8.54	2.82	5.02	3.19	8.31	3.42	5.30	6.38	6.10	60.02
	Mean	3.37	3.39	2.92	4.14	5.05	3.39	2.78	4.11	3.31	4.25	4.37	4.17	45.25
Fort Columbus.	1849	0.61	2.26	4.87	0.62	3.47	0.78	1.43	4.63	1.55	5.63	1.88	4.01	31.74
	1850	5.57	2.64	4.64	2.72	9.20	3.07	3.92	7.21	4.71	3.16	2.33	5.36	54.53
	1851	1.46	4.50	1.70	6.94	4.73	0.90	4.72	3.47	1.26	2.95	4.53	3.72	39.97
	1852	2.92	3.08	4.43	4.74	2.24	2.11	3.25	6.20	2.29	2.06	6.07	4.45	43.84
	1853	4.14	4.98	2.03	3.32	5.80	4.80	4.40	5.50	5.49	3.90	6.80	1.04	52.20
	1854	2.60	4.00	0.70	8.80	7.70	2.20	1.90	1.03	1.90	1.80	3.95	8.60	45.18
	Mean	2.78	2.92	3.44	3.33	4.78	3.46	3.17	4.70	3.31	3.40	3.59	3.93	42.23
Fort Niagara.	1850	4.01	0.67	0.49	0.46	0.70	6.64	6.37	5.17	7.25	3.10	3.06	1.82	39.74
	1851	1.20	3.32	0.37	2.01	2.49	1.69	3.18	2.26	2.99	2.58	2.40	1.42	25.91
	1852	1.00	1.71	4.46	2.87	2.56	2.91	1.98	2.60	5.06	3.30	2.62	5.97	37.04
	1853	1.11	1.64	2.54	3.40	3.70	1.60	2.71	1.56	3.55	1.31	2.18	1.17	26.47
	Mean	2.25	1.89	2.12	2.20	2.55	3.28	3.49	3.04	3.95	2.37	2.36	2.27	31.77
Alleghany Arsenal.	1850	3.76	3.45	2.74	2.59	3.30	2.62	2.82	1.27	3.62	4.29	2.19	4.76	37.41
	1851	0.35	3.01	1.43	2.83	3.57	2.04	4.30	2.66	2.62	1.45	3.67	1.71	29.74
	1852	1.80	3.34	2.03	9.27	3.84	2.76	2.55	2.76	3.09	2.24	2.67	5.01	41.36
	1853	1.56	3.53	1.11	4.16	3.27	1.32	2.74	6.56	2.34	2.04	2.90	2.10	33.63
	1854	2.23	2.33	2.82	4.21	2.24	2.06	1.45	1.13	1.76	2.89	1.88	1.67	26.67
	Mean	2.18	2.17	2.70	3.10	3.58	3.56	2.97	3.34	2.68	2.87	2.68	3.13	34.96
Fort McHenry.	1850	3.58	2.43	5.90	3.85	3.08	1.66	3.10	4.70	4.70	3.10	4.30	4.40	43.80
	1851	1.70	2.90	5.70	4.70	4.60	1.20	4.20	3.30	0.50	2.20	5.60	1.50	38.10
	1852	2.60	3.60	3.90	7.80	1.70	2.70	5.70	4.60	2.20	2.60	7.90	6.20	51.50
	1853	1.30	3.40	2.70	3.10	4.30	0.60	3.30	4.70	2.40	4.40	3.50	2.30	36.00
	Mean	2.64	2.70	3.86	3.56	3.71	3.28	3.50	4.26	3.31	3.53	3.68	3.97	42.00
Fort Moultrie.	1850	2.95	2.83	6.01	2.59	4.10	0.78	2.32	4.03	2.68	0.88	1.99	4.64	35.80
	1851	3.67	2.51	1.93	1.65	0.63	8.25	8.57	5.89	0.29	1.28	3.34	1.10	39.11
	1852	0.51	1.21	4.35	2.96	4.17	8.86	5.43	4.15	11.70	1.20	2.12	4.60	51.26
	1853	1.91	2.80	3.30	1.06	2.53	1.55	10.88	2.20	8.10	4.05	4.89	2.39	45.65
	1854	3.80	2.84	0.25	2.20	3.70	4.20	5.69	3.82	9.24	1.12	1.16	1.74	39.76
	Mean	2.39	2.33	4.06	1.75	4.08	4.15	6.72	6.58	5.83	2.44	1.79	2.80	44.92
Key West.	1851	2.40	0.88	1.50	1.80	5.32	9.24	3.24	6.80	14.00	9.45	2.30	2.64	59.57
	1852	1.82	3.67	8.74	2.17	0.40	8.51	6.16	6.03	6.22	4.18	3.00	3.41	54.31
	1854	1.77	2.55	0.51	2.99	3.14	4.54	3.45	5.83	9.70	4.73	0.25	8.45	47.91
	Mean	2.86	1.38	4.21	1.55	2.58	8.29	3.35	4.95	7.79	6.38	1.18	3.13	47.65
Fort Brooke.	1852	0.95	0.85	6.40	3.05	3.06	13.20	10.95	14.03	10.00	0.30	3.20	3.00	69.26
	1853	4.55	1.60	3.35	0.75	0.30	9.09	4.12	4.67	4.36	1.70	2.90	7.38	44.77
	1854	3.83	6.89	2.44	8.82	6.21	9.44	15.11	11.23	4.68	1.77	1.75	4.85	77.44
	Mean	2.20	3.01	3.37	1.95	3.24	7.04	11.10	10.10	6.23	2.40	2.00	2.83	55.47

RAINFALL OF NORTH AMERICA.

DETAILS OF MONTHLY FALL

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Period.		Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Mt. Vernon Arsenal.	1849	2.89	2.44	2.36	3.06	6.11	9.25	14.56	11.15	0.65	13.0	10.54	4.22	79.23
	1850	9.49	4.81	2.09	4.22	6.72	2.01	6.44	5.13	0.15	0.85	2.32	5.22	48.55
	1851	3.89	7.26	0.77	1.14	3.44	5.35	1.84	8.69	4.42	2.07	6.99	2.91	48.77
	1852	1.91	1.95	1.52	6.24	6.75	1.56	1.91	9.64	0.70	2.40	9.74	7.15	51.49
	Mean	6.80	6.04	4.59	4.21	4.62	6.14	6.30	6.40	3.05	3.91	6.18	5.25	63.50
Baton Rouge.	1851	0.97	5.27	1.54	2.26	1.42	2.06	2.68	7.96	0.59	2.32	8.91	5.36	41.34
	1852	1.56	6.73	2.19	8.29	6.08	1.33	5.64	2.26	3.30	2.81	9.32	3.95	53.46
	1854	2.85	5.50	6.15	3.58	8.05	4.00	6.55	7.41	9.88	4.38	0.45	1.82	60.62
	Mean	5.26	4.91	4.68	5.22	5.18	5.52	7.41	6.20	3.50	2.67	5.90	5.23	62.10
Fort Towson.	1850	4.03	4.07	2.85	4.79	2.04	5.06	3.29	4.39	2.66	5.19	6.21	5.07	49.64
	1853	1.72	2.90	3.88	4.99	9.05	0.90	5.38	0.49	6.11	3.40	1.97	1.27	42.10
	Mean	3.13	2.97	4.38	5.33	5.84	5.78	4.62	3.96	3.41	4.59	4.23	2.84	51.08
Fort Gibson.	1850	1.40	3.17	4.91	4.73	0.37	4.58	1.00	3.00	0.35	3.75	4.75	3.00	35.00
	1851	0.50	10.42	1.50	0.50	3.20	6.45	8.25	1.15	3.14	9.35	7.10	7.70	52.46
	1852	1.58	5.67	2.24	2.95	6.72	5.85	6.12	4.99	4.38	5.50	4.91	0.74	51.65
	1853	0.82	2.27	1.06	3.52	6.65	1.60	0.76	4.72	1.35	1.13	1.30	0.70	25.88
	1854	0.30	1.43	7.83	3.16	7.67	2.80	0.21	0.33	0.68	1.58	2.06	0.77	28.82
	Mean	1.83	2.26	2.54	4.19	4.65	4.30	2.75	2.63	2.30	3.85	3.10	2.06	36.46
Fort Scott.	1850	1.59	1.52	2.40	3.13	2.19	4.80	0.27	5.45	0.52	1.56	4.39	2.21	30.01
	1851	0.14	3.60	0.48	0.75	4.39	7.53	2.74	3.89	0.15	2.01	5.49	1.84	32.41
	1852	2.22	0.11	0.98	2.17	10.74	0.36	4.45	2.90	2.40	6.23	5.98	1.98	46.52
	Mean	1.92	1.18	1.79	3.70	7.08	8.13	4.55	3.69	2.30	2.66	3.43	1.69	42.11
Jefferson Barracks.	1850	1.65	3.22	4.66	5.02	3.46	1.52	2.93	5.20	2.75	1.75	4.11	3.32	39.61
	1851	0.40	5.05	1.86	2.80	3.97	5.64	4.65	7.06	0.81	2.26	0.38	1.25	36.13
	1852	3.34	1.73	7.19	1.39	8.12	11.85	2.72	3.24	2.97	4.81	3.80	3.97	55.13
	Mean	1.91	2.04	3.32	3.06	4.18	5.07	3.67	4.14	2.88	2.76	2.38	2.42	37.83
Detroit.	1845	1.71	0.63	1.89	3.29	1.03	2.30	1.92	1.32	3.82	1.60	1.50	0.50	21.51
	1849	2.81	1.01	2.57	2.90	2.10	3.96	2.35	4.35	3.25	6.00	1.82	0.90	33.49
	1850	1.58	1.56	3.84	2.00	0.29	2.65	2.85	3.56	2.11	1.11	2.36	1.49	25.40
	Mean	2.18	1.38	2.86	2.92	2.73	3.91	3.20	2.18	3.31	2.04	2.06	1.30	30.07
Fort Brady.	1850	1.83	0.83	1.83	2.15	0.70	2.92	8.15	4.09	4.90	4.00	1.35	2.91	35.56
	1851	2.74	1.28	0.84	2.23	3.11	2.91	5.99	3.67	4.82	4.04	6.12	7.55	45.30
	1853	0.92	1.19	0.48	0.73	0.74	3.94	3.27	3.19	2.61	2.16	1.77	0.74	21.74
	1854	2.49	1.18	1.34	2.14	3.61	1.23	3.21	3.86	3.18	3.40	3.07	0.45	29.16
	Mean	1.84	1.13	1.37	1.83	2.24	2.83	3.75	3.39	4.33	3.35	3.08	2.21	31.35
Fort Hwrd.	1851	1.12	1.50	0.78	1.58	8.50	3.15	5.07	2.67	3.26	1.10	2.26	0.28	31.47
	Mean	1.19	0.87	1.70	3.33	3.97	4.93	5.51	4.01	3.11	2.36	2.37	1.30	34.65
Fort Snelling.	1850	1.67	0.83	2.23	2.60	0.57	4.62	6.15	2.97	1.82	0.32	1.68	0.04	25.50
	1851	0.20	0.13	1.23	2.68	3.96	2.15	2.60	3.29	3.64	1.18	2.31	0.05	23.42
	1852	0.06	0.14	2.04	2.49	4.72	0.08	2.74	0.89	0.72	0.82	0.22	0.15	15.07
	1853	0.00	0.01	0.02	0.73	4.08	7.59	1.65	2.57	2.14	0.01	0.56	1.11	20.47
	1854	0.72	0.03	1.03	2.51	4.30	3.31	3.92	1.75	6.55	1.23	0.60	0.64	26.59
	Mean	0.73	0.52	1.30	2.14	3.17	3.63	4.11	3.18	3.32	1.35	1.31	0.67	25.43

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Period.		Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Fort Leavnwth	1850	1.10	2.21	3.64	1.74	2.32	5.99	1.63	2.27	0.72	1.85	3.84	0.76	27.07
	1851	0.54	0.96	1.03	1.00	6.40	8.16	6.78	5.02	1.10	1.68	3.18	1.96	38.81
	1852	0.96	0.28	1.35	5.50	4 71	6.53	4.60	4.22	1.61	2.64	3.53	0.60	36.53
	1853	0.01	0.30	0.15	2.36	3.39	5.95	3.21	5.01	1.47	0.52	2.07	0.76	25.20
	1854	0.04	1.78	1.33	3.35	5.55	4.50	0.18	1.07	2.11	3.20	1.20	0.09	24.40
	Mean	0.72	1.01	1.61	2.74	3.62	5.80	3.15	3.29	3.22	1.84	2.17	1.02	30.29
Fort Laramie	1852	0.72	1.10	1.55	1.25	7.29	4.08	1.88	1.46	2.74	1.70	6.42	1.23	31.42
	1853	0.08	0.57	1.78	4.53	12.19	4.95	1.86	0.55	2.80	0.68	0.08	0.71	30.78
	1854	0.18	0.40	0.80	3.98	4.46	3.67	3.26	1.27	1.60	1.86	0.73	0.05	22.26
	Mean	0.33	0.69	1.37	3.32	7.98	4.23	2.34	1.09	2.38	1.42	2.41	0.66	28.22
Fort Brown.	1850	4.30	3.80	2.30	0.05	2.20	0.06	1.16	0.01	0.25	5.79	0.69	0.15	20.76
	1851	0.95	1.20	0.40	1.15	0.90	2.35	3.65	1.80	5.60	4.10	3.00	4.70	29.30
	1852	0.50	0.60	0.35	0.00	4.05	5.05	0.70	3.90	8.50	4.95	0.90	0.00	29.50
	1853	0.00	1.60	0.00	2.20	0.10	1.70	0.00	3.10	8.00	7.75	1.30	0.65	26.40
	1854	0.45	1.50	1.16	0.05	4.10	7.65	4.25	5.00	11.31	5.79	7.47	1.88	50.60
	Mean	1.61	2.25	1.20	0.56	2.21	4.55	1.95	2.76	6.73	5.68	2.67	1.48	33.65
Ringgold Barracks.	1850	3.14	0.61	1.93	0.79	4.55	2.76	0.17	0.11	0.08	0.58	2.91	0.01	17.64
	1851	0.84	0.69	0.03	1.21	0.20	1.21	2.20	0.02	5.21	1.20	0.12	1.15	14.08
	1852	1.00	0.88	0.65	0.68	2.28	0.96	0.82	1.44	4.24	4.78	0.01	0.08	17.82
	1853	0.70	2.33	0.00	3.79	3.91	1.45	0.15	4.34	2.32	2.40	0.19	0.91	22.58
	1854	0.70	1.69	0.22	0.09	2.83	11.00	4.06	1.58	3.02	0.92	2.10	0.68	29.05
	Mean	1.24	1.18	0.72	1.08	2.69	3.47	2.13	1.50	3.22	2.15	0.94	0.63	20.95
Fort Clrke.	1853	0.88	1.18	0.65	2.50	1.16	10.21	3.87	2.75	0.13	4.00	0.21	1.60	29.14
	1854	0.00	0.94	1.48	0.60	2.65	0.11	0.08	0.95	3.49	0.55	3.22	0.35	14.42
Fort Fil-more	1853	0.04	0.10	0.03	0.01	0.05	0.28	2.80	1.83	1.21	0.90	1.15	0.64	9.64
	1854	0.00	0.00	0.65	0.10	0.86	0.05	0.87	1.38	0.95	0.39	0.07	0.15	6.07
Fort Con-rad.	1853	0.23	0.39	0.38	0.00	0.35	0.74	2.78	1.20	0.53	0.00	0.59	0.67	7.86
	1854	0.00	0.00	0.05	0.01	0.62	0.01	0.41	1.02	2.13	0.34	1.09	0.08	5.76
Fort Albu-querq.	1853	0.00	0.00	0.01	0.00	0.04	0.00	2.57	3.80	0.07	0.00	0.31	0.30	7.10
	1854	0.30	0.00	0.43	0.39	1.19	0.28	2.59	1.19	2.67	1.37	1.35	0.92	12.51
Fort Union.	1852	0.48	0.59	0.00	0.24	0.73	7.05	2.73	5.49	3.04	3.44	2.83	0.02	26.64
	1853	0.19	0.08	0.77	0.32	0.91	0.11	4.19	3.42	1.59	1.29	0.38	0.18	13.43
	1854	0.07	0.02	0.63	0.46	0.50	0.69	3.98	1.75	2.99	0.88	1.80	0.60	14.37
	Mean	0.19	0.99	0.37	0.53	1.57	2.00	4.07	3.55	2.45	1.25	1.42	0.85	19.24
Fort Defi-ance.	1853	0.40	0.08	1.29	0.10	1.44	0.43	1.43	4.65	2.64	0.94	0.22	0.25	13.87
	1854	2.00	0.15	0.45	0.93	0.51	1.24	3.94	5.24	3.47	0.62	1.49	1.20	20.84
	Mean	1.08	0.65	1.68	0.51	0.72	1.11	1.57	3.73	2.64	1.05	0.98	0.92	16.64
Fort Yuma.	1853	0.00	0.00	0.01	0.00	0.00	0.00	0.25	0.69	0.13	0.00	0.18	0.52	1.78
	1854	0.00	0.28	0.80	0.00	0.00	0.00	0.01	2.37	0.17	0.30	0.00	0.57	4.50
San Die-go.	1853	0.50	0.20	1.52	0.25	2.10	0.05	0.00	0.21	0.00	0.00	1.28	1.77	7.88
	1854	1.46	2.56	2.14	0.75	0.21	0.02	0.07	1.35	0.13	0.01	0.02	3.34	12.06
Fort Miller	1852	0.42	0.61	15.59	2.59	0.60	0.00	0.00	0.00	0.07	0.07	8.80	20.60	49.35
	1853	1.20	2.35	5.54	2.25	4.79	0.00	0.01	0.00	0.00	0.00	1.26	1.00	18.40
	1854	2.26	2.42	0.85	2.08	0.04	0.01	0.00	0.00	0.12	0.68	0.00	1.25	0.00

RAINFALL OF NORTH AMERICA.

DETAILS OF MONTHLY FALL

At some of the principal Stations referred to in the table of Annual Rainfall.

NOTE.—The Means are those of the number of years named in the table of Annual Rainfall, not of the more limited years, of which the detail is here given. The Rain at Toronto includes the Snow shewn in the Table following, being taken at one-eighth of that measure.

Period.		Jan.	Feb.	Mar.	Aprl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
San Francisco.	1852	...	...	...	...	...	...	0.00	0.00	0.00	0.69	4.92	12.07	...
	1853	3.75	1.17	3.72	5.27	0.42	0.00	0.00	0.00	0.23	0.28	2.00	1.86	18.70
	1854	3.04	5.87	3 11	2.24	0.06	1.05	0.01	0.03	0.03	1.56	0.40	0.60	17.00
Fort Reading.	1852	...	...	...	2.87	...	1.06	0.00	0.00	0.00	0.48	8.48	11.18	...
	1853	4.66	3.18	7.11	4.57	0.73	0.00	0.00	0.24	0.02	0.02	2.52	2.18	25.23
	1854	2.90	2.15	0.80	3.07	2.40	0.00	0.01	0.00	0.00	2.26	0.87	1.45	15.91
Fort Vancouver.	1852	9.31	4.77	4.26	6.56	3.49	1.77	...	...	...	1.55	7.37	13.37	...
	1853	9.30	4.21	2.47	1.72	2.33	0.90	0.30	0.39	2.00	3.66	11.57	3.22	42.07
Fort Dallas, Columbia.	1853	3.02	1.09	0.27	1.29	0.62	0.00	0.08	0.61	1.41	0.24	4.90	0.95	14.48
	1854	2.79	0.73	0.36	1.52	0.00	0.15	0.00	0.18	0.84	1.91	1.41	2.50	11.39
Fort Steilacoom.	1850	8.52	4.83	6.70	1.00	0.30	0.40	0.20	0.00	1.20	2.40	5.14	2.62	33.31
	1851	15.30	1.47	2.20	3.09	1.95	0.55	0.36	0.81	2.68	3.96	3.02	3.93	39.32
	1852	11.50	5.43	5.12	3.34	0.12	0.82	0.93	1.78	1.02	3.72	6.17	8.84	48.79
	1853	8.14	3.24	2.62	1.57	2.08	3.09	0.23	1.19	4.99	6.93	18.41	4.42	57.01
	1854	8.69	7.57	2.89	12.50	0.88	5.68	0.00	3.93	3.46	4.37	7.37	12.87	69.21
	Mean	9.54	5.16	4.56	4.77	1.86	1.97	0.34	1.54	2.67	4.28	8.25	6.81	51.75
TORONTO. Rain and Snow.	1850	1.91	4.13	2.14	4.86	0.54	3.34	5.27	4.36	1.73	2.08	2.96	3.89	37.22
	1851	2.24	2.90	1.87	2.45	3.02	2.69	3.63	1.36	2.66	1.72	4.72	2.41	31.67
	1852	3.86	2.27	5.52	3.16	1.12	3.16	4.03	2.70	3.63	5.29	2.02	6.50	43.26
	1853	1.23	2.60	1.97	2.75	4.42	1.55	9.15	2.57	5.14	0.87	2.76	3.41	38.41
	1854	2.21	3.71	2.77	2.81	4.62	1.46	4.81	0.46	5.37	1.49	1.27	2.74	33.72
	1855	3.43	4.50	3.74	2.37	2.67	4.07	3.24	1.45	5.58	2.50	4.96	5.53	44.02
	1856	1.70	1.21	2.03	2.98	4.58	3.20	1.12	1.68	4.10	0.88	2.56	3.83	29.87
	1857	2.72	4.51	1.74	3.36	4.15	5.06	3.47	5.27	2.64	1.07	4.09	4.34	42.42
	1858	1.65	3.34	0.95	1.65	6.37	2.94	3.07	3.89	0.73	1.80	4.38	2.96	33.73
	1859	3.50	1.49	4.18	2.68	3.41	4.08	2.61	3.99	3.52	0.94	5.27	5.71	41.38
	Mean	2.58	3.22	2.48	2.74	3.50	2.85	3.71	2.68	3.64	2.48	3.51	3.70	37.11
TORONTO. Snow.	1850	5.02	23.1	11.2	1.01	...	...	...	...	...	...	...	29.5	70.01
	1851	7.08	2.4	8.8	1.02	0.05	...	...	...	...	0.03	6.07	10.7	38.04
	1852	30.09	13.0	19.5	9.04	...	...	...	...	...	...	2.00	20.1	94.09
	1853	7.05	12.6	7.1	1.00	...	...	...	...	...	...	2.07	22.3	53.02
	Mean	12.01	14.1	9.8	2.09	0.01	...	...	...	...	0.01	2.05	18.4	59.09
St. Martin, Montreal.	1853	2.91	6.89	2.43	3.77	6.39	3.13	3.11	6.95	10.11	5.71	5.46	1.95	58.81
	1854	3.30	3.14	4.48	8.39	3.39	8.38	0.17	2.26	6.16	4.84	5.27	2.44	52.21
	1855	3.94	1.87	2.48	4.71	0.75	8.41	2.35	4.36	3.47	9.01	4.96	5.52	51.83
	1856	3.40	1.45	1.43	...	...	4.32	6.37	9.91	3.57	...	...	...	...
	1857	2.39	3.96	2.86	7.42	4.26	6.21	5.75	...	...	6.82	6.00	4.70	...
	1858	2.22	2.20	0.81	3.18	5.39	8.66	12.21	4.02	5.84	5.63	3.89	3.20	57.25
	1859	2.07	3.45	3.55	4.92	3.86	6.78	2.43	6.67	11.31	1.92	10.17	4.46	61.59
	Mean	2.89	3.28	2.58	5.40	4.01	6.55	4.63	5.69	6.74	5.65	5.96	3.71	56.34
Quebec.	1853	...	...	...	...	...	4.91	4.74	4.98	7.06	2.94	6.19	2.57	...
	1854	5.19	5.49	7.10	4.30	...	...	...	...	...	6.98	6.32	5.07	...
	1855	6.74	3.81	2.70	6.18	2.11	7.06	4.32	10.33	3.72	9.25	5.99	5.30	67.51
Kingston.	1856	2.12	0.31	2.25	0.86	4.04	1.84	1.24	2.05	4.51	0.71	0.64	0.85	21.43
	1857	2.50	2.09	2.06	3.28	2.47	2.33	2.38	6.00	1.66	1.98	3.36	2.52	32.63
	1858	1.77	1.81	2.40	2.30	2.64	3.08	4.53	3.39	2.50	1.81	1.35	2.21	29.79
	Mean	2.13	1.40	2.24	2.15	3.05	2.42	2.72	3.81	2.89	1.50	1.78	1.86	27.95
Halifax		2.72	3.86	40.1	5.37	4.69	1.86	3.85	5.69	5.07	4.46	5.59	8.14	55.31

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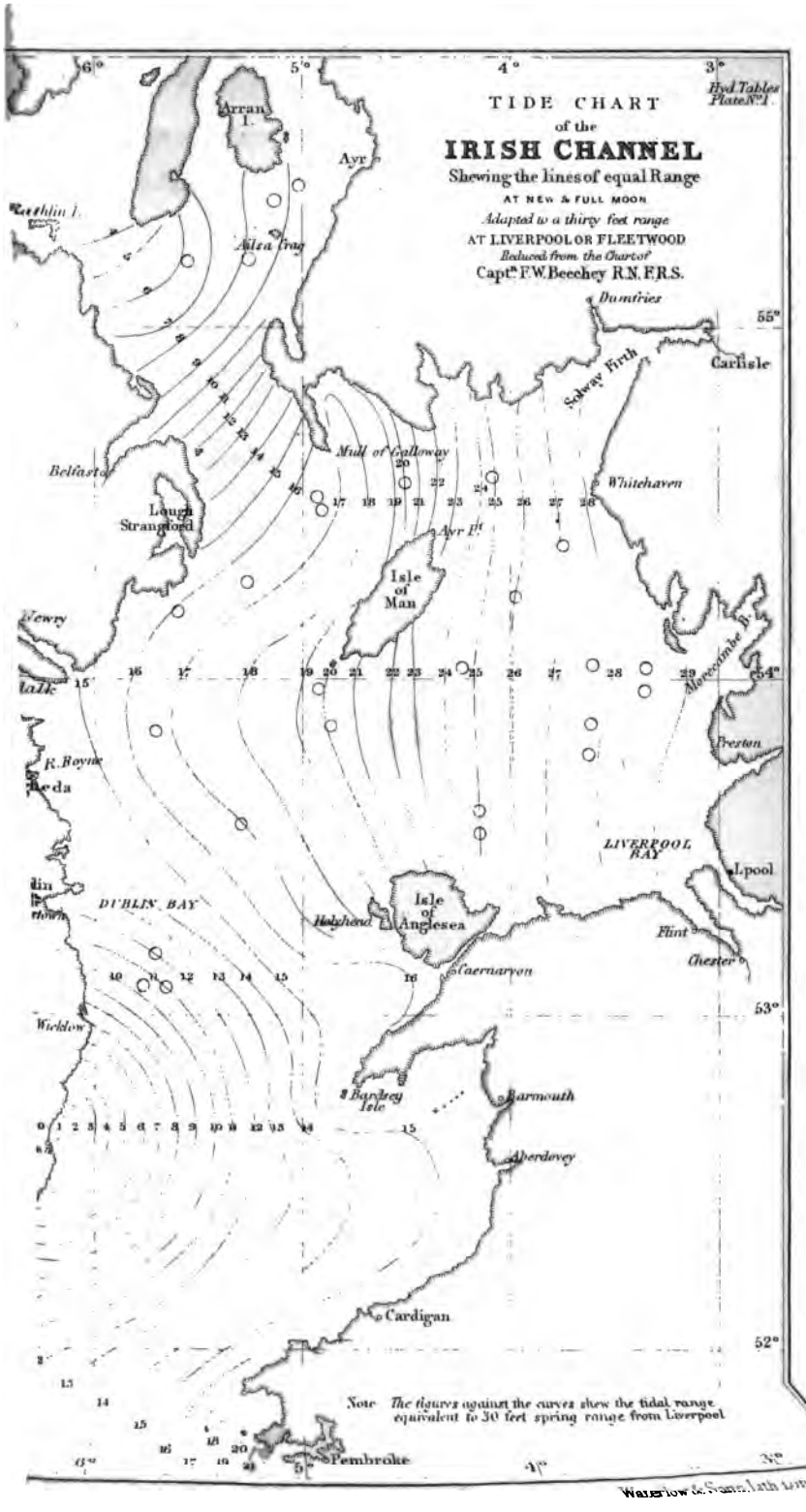
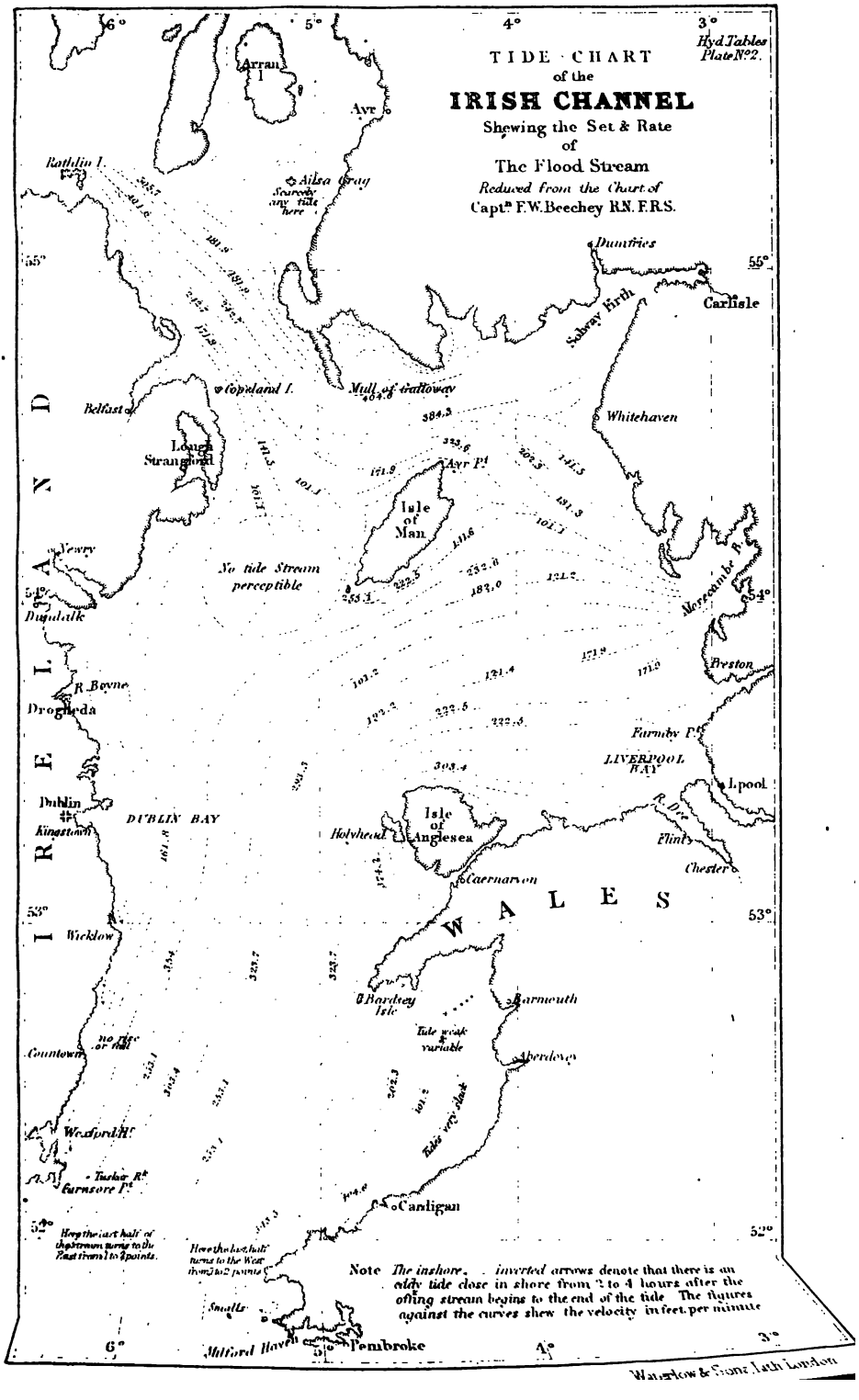
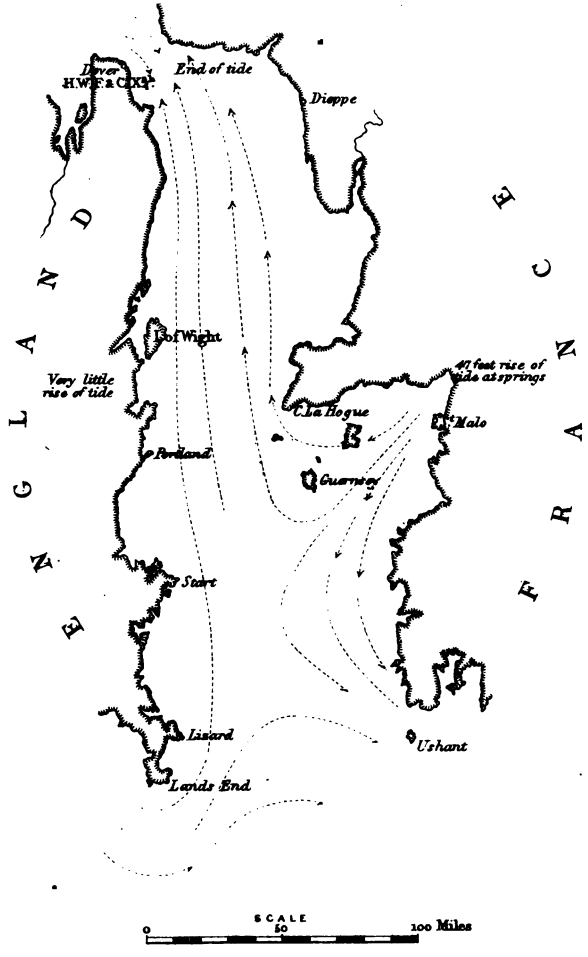

TIDE CHART
of the
IRISH CHANNEL
Shewing the lines of equal Range
AT NEW & FULL MOON
Adapted to a thirty feet range
AT LIVERPOOL OR FLEETWOOD
Reduced from the Chart of
Capt.n F.W.Beechey R.N. F.R.S.
Hyd.Tables Plate N.o I.
Arran I.
Ayr
Ailsa Craig
Belfast
Lough Strangford
Mull of Galloway
Dumfries
Carlisle
Solway Firth
Whitehaven
Ayr H.d
Isle of Man
Newry
Morecambe B.
Preston
R. Boyne
Leda
LIVERPOOL BAY
L.pool
DUBLIN BAY
Holyhead
Isle of Anglesea
Flint
Chester
Caernarvon
Wicklow
Barmouth
Bardsey Isle
Aberdovey
Cardigan
Pembroke
Note The figures against the curves shew the tidal range equivalent to 30 feet spring range from Liverpool


TIDE CHART
of the
IRISH CHANNEL
Shewing the Set & Rate
of
The Flood Stream
Reduced from the Chart of
Capt.n F.W.Beechey R.N. F.R.S.
Hyd.l Tables
Plate No.2.
6°
5°
4°
3°
55°
54°
53°
52°
Arran I.
Ayr
Ailsa Craig
Sounds any Tide here
Rathlin I.
Dumfries
Carlisle
Solway Firth
Belfast
Copeland I.
Mull of Galloway
Whitehaven
Lough Strangford
Ayr Pt
Isle of Man
Newry
No tide Stream perceptible
Morecambe B.
Dundalk
Preston
R. Boyne
Drogheda
Formby Pt
LIVERPOOL BAY
L.pool
Dublin
Kingstown
DUBLIN BAY
Isle of Anglesea
Holyhead
R. Dee
Flint
Chester
Caernarvon
IRELAND
WALES
Wicklow
Bardsey Isle
Barmouth
Tide weak & variable
Aberdovey
Courtown
no Tide or flow
Wexford H.r
Tuskar R.k
Carnsore Pt
Tide very slack
Cardigan
Keep the last half of the stream turning to the East from 1 to 2 points.
Here the last half turns to the West from 1 to 2 points
Smalls
Milford Haven
Pembroke
Note The inshore inverted arrows denote that there is an eddy tide close in shore from 2 to 4 hours after the offing stream begins to the end of the tide. The figures against the curves shew the velocity in feet per minute
Waterlow & Sons Lith. London

SKETCH
of the
Course of the 7 o'clock stream of Tide
in the
ENGLISH CHANNEL
Reduced from a plan made by
Capt.ⁿ Beechey R.N.
in 1848.



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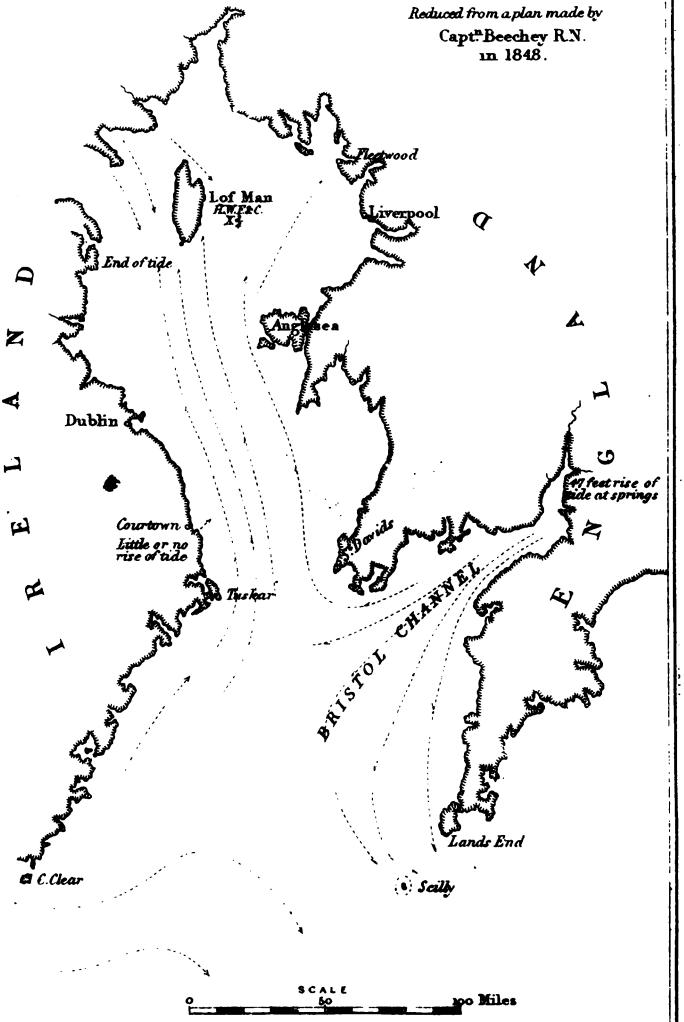
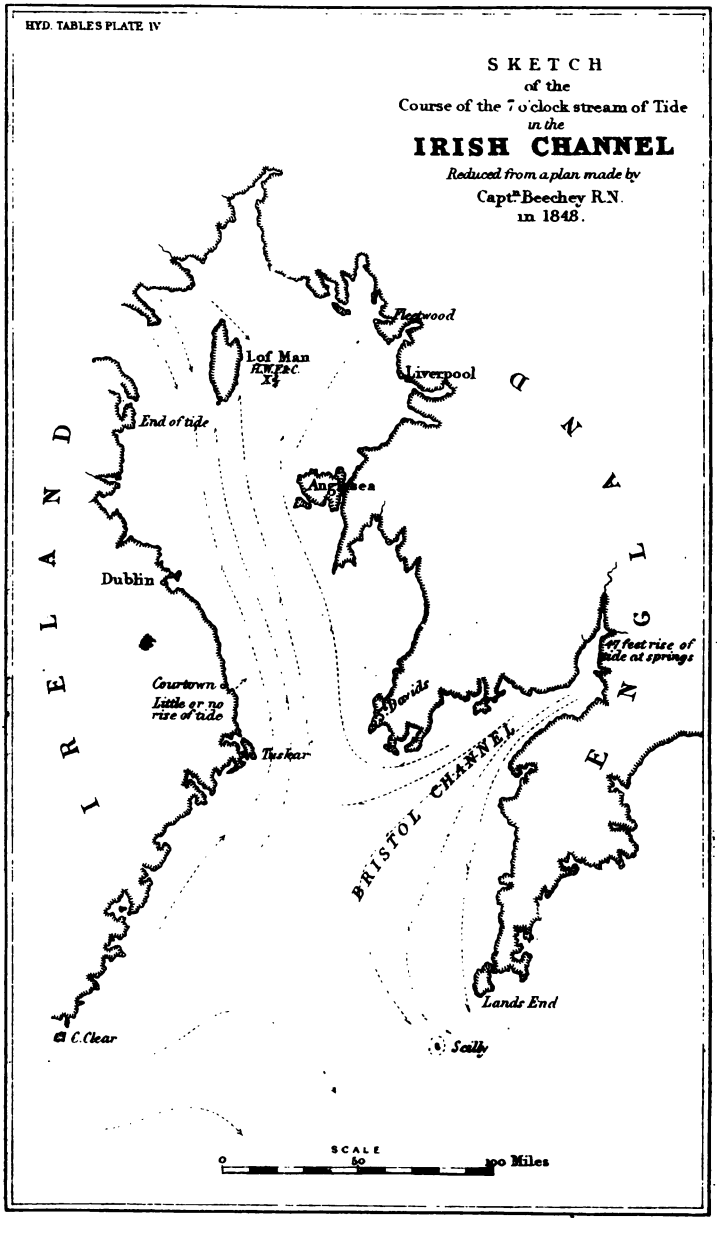
HYD. TABLES PLATE IV

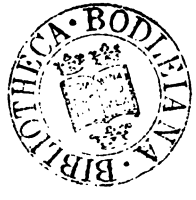
SKETCH
of the
Course of the 7 o'clock stream of Tide
in the
IRISH CHANNEL
Reduced from a plan made by
Capt.ⁿ Beechey R.N.
in 1848.



BIBLIOTHECA BODLEIANA

HYD. TABLES PLATE IV

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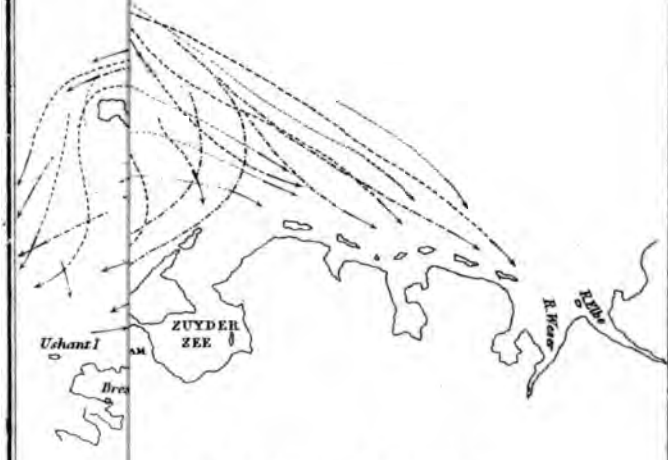
HYD. TABLES, PLATE IV A
RISING TIDE

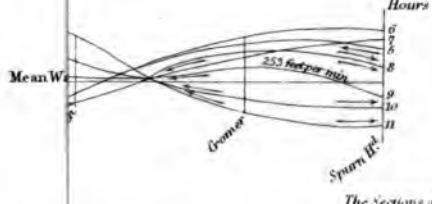


I OF THE ENGLISH CHANNEL

ing the direction of the tidal currents
rious hours before High Water at Dover.
Current 5 hours before H.W. shewn thus .....
3 .....
1 .....

n charts by the late Admiral Beechy F.R.S.

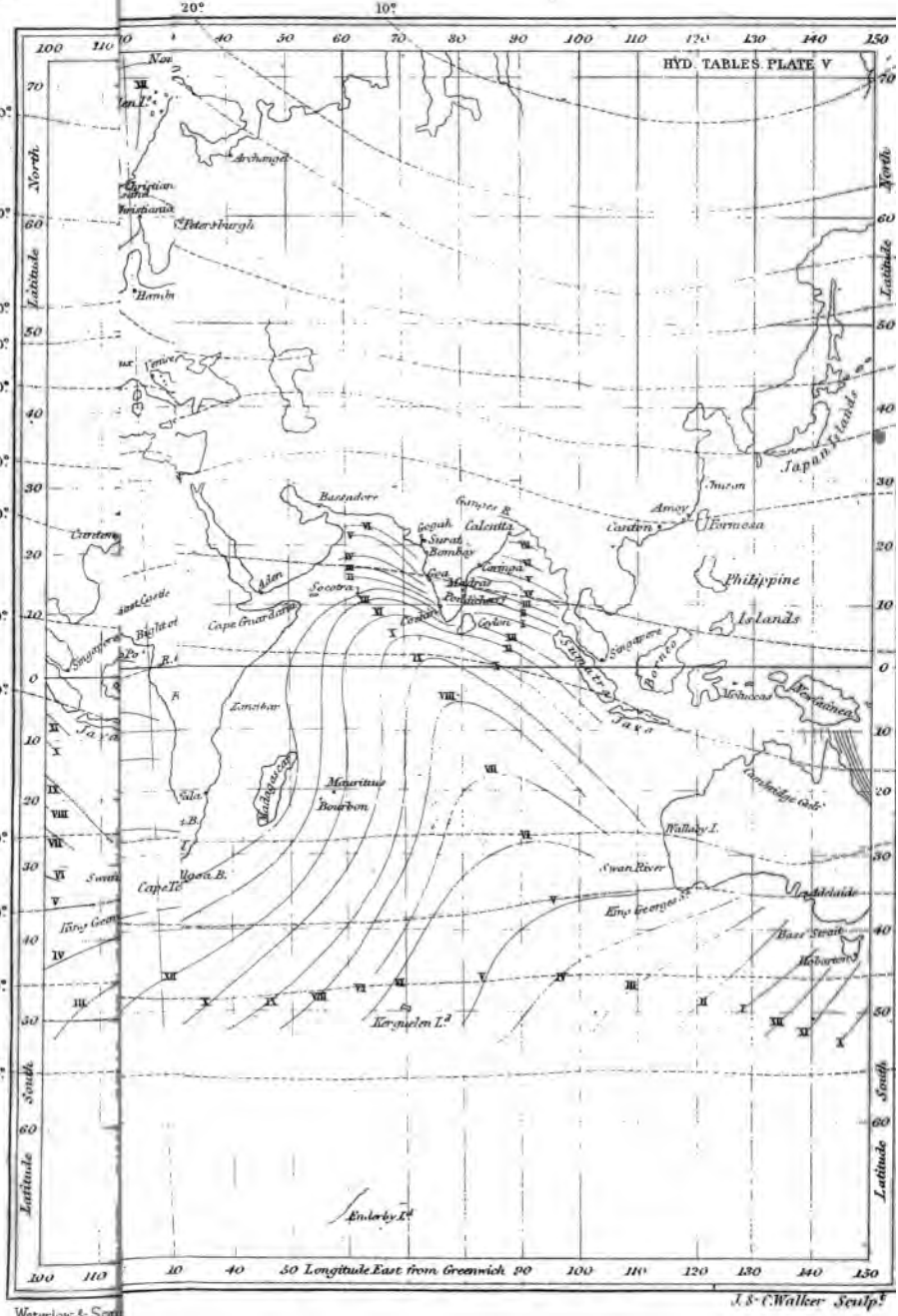
Isles to Spurn Head



The Sections are the mean of the wave lines on the English and French coast

C. K. Oliver del.

Engraved by Jas Walker


HYD. TABLES PLATE V
Longitude East from Greenwich
Latitude North
Latitude South
Archangel
Petersburgh
Hamburgh
Bassadore
Calcutta
Surat
Bombay
Goa
Madras
Pondicherry
Ceylon
Socotra
Cape Guardafui
Cape of Good Hope
Table B.
Java
Sumatra
Borneo
Philippine Islands
Japan Islands
Moluccas
New Guinea
Madagascar
Mauritius
Bourbon
Amsterdam I.
St Paul I.
Kerguelen I.d
Enderby I.d
Swan River
King Georges Sd
Adelaide
Van Diemens Land
Cape Leeuwin
Yorke B.
Sala B.
Endeavour Str.
Torres Str.
Banks Str.
Hobart Town
Waterlow & Sons
J. & C. Walker Sculp.t

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Nº 1 Nº 2 &c. are the tidal Stations from which the diagram is made the High & Low Waters in the Cross Sections are those of June 3rd 1844.

Fiddlers Ferry
H.W. 1h 50m P.
Width 600 F.
Nº 6

Warrington Bridge H.W. 4h 30m
Width 750 F.
Nº 7

Feet

30 — 35 Miles

River Surface at Low Water

Nº 3
Cross Section below Rock Ferry
High Water
Low Water

Nº 4
Cross Section above Rock Ferry
High Water
Low Water

of 1857
1822

Nº 5
Cross Section at Pool Hall
High Water
Low Water

J. & C. Walker Sculp.

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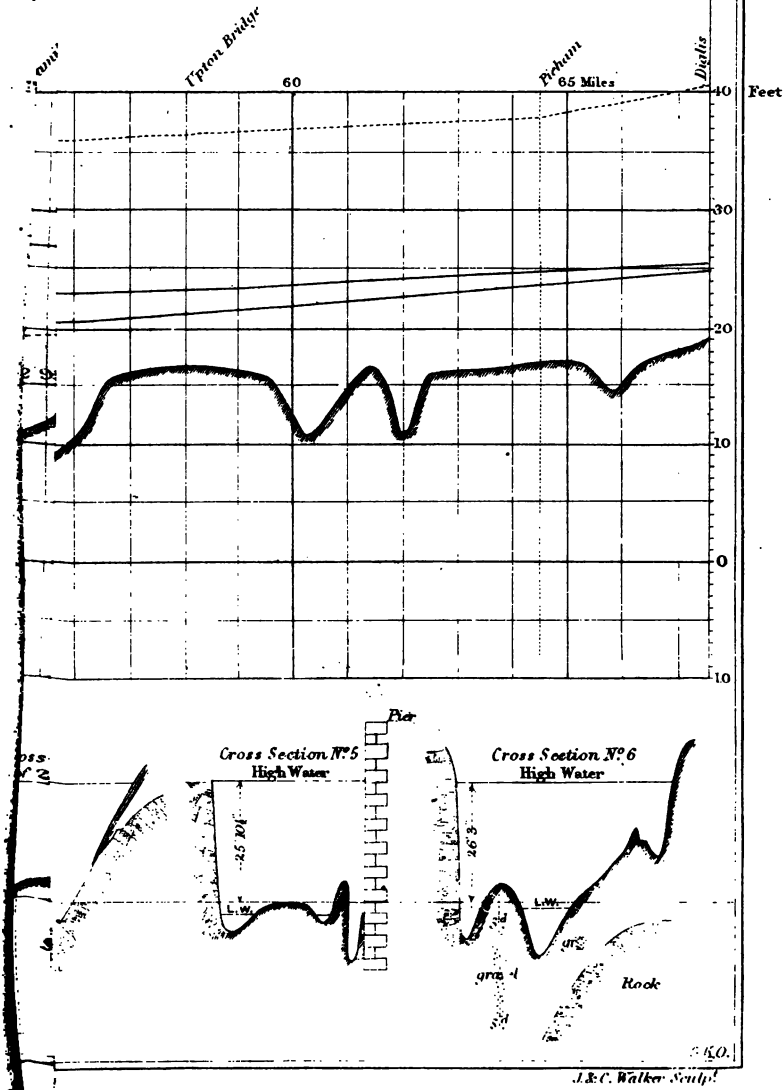
HYD. TABLES PLATE VII



J.&C. Walker Sculp!

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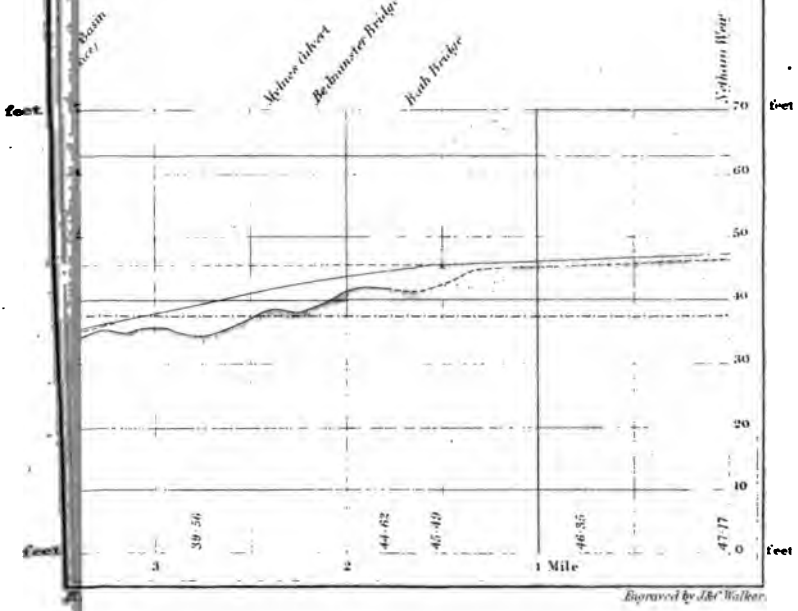

Engraved by J.&C. Walker.

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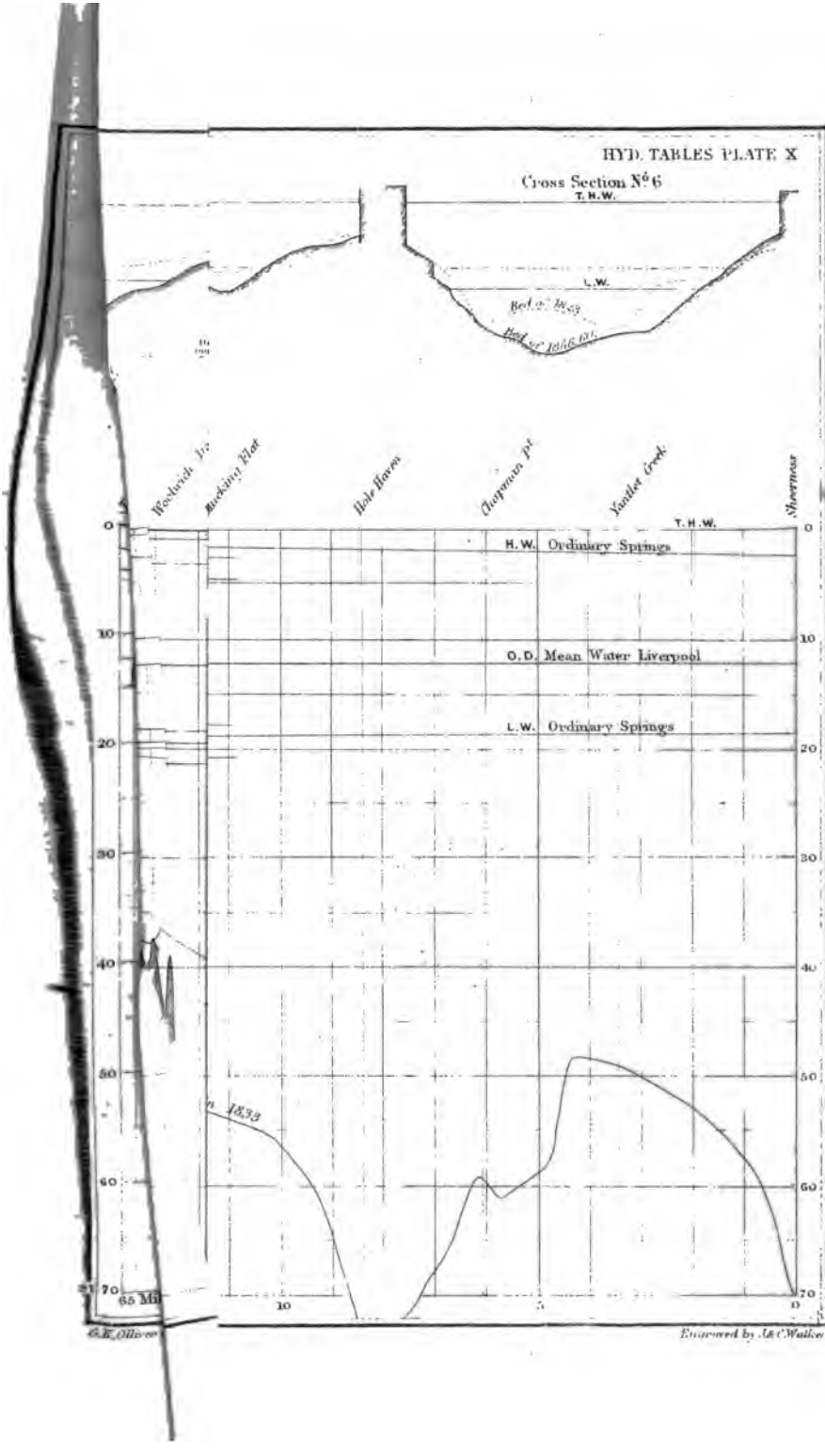
HYD. TABLES PLATE X
Cross Section N° 6
T. H.W.
L.W.
Bed of 1833
Bed of 1846-61
Woolwich Pr
Rocking Flat
Hole Haven
Chapman pt
Yantlet Creek
Shoeburness
T. H.W.
H.W. Ordinary Springs
O.D. Mean Water Liverpool
L.W. Ordinary Springs
1833
65 Mi
10
5
0
G.E. Ollivier
Engraved by A. C. Walker

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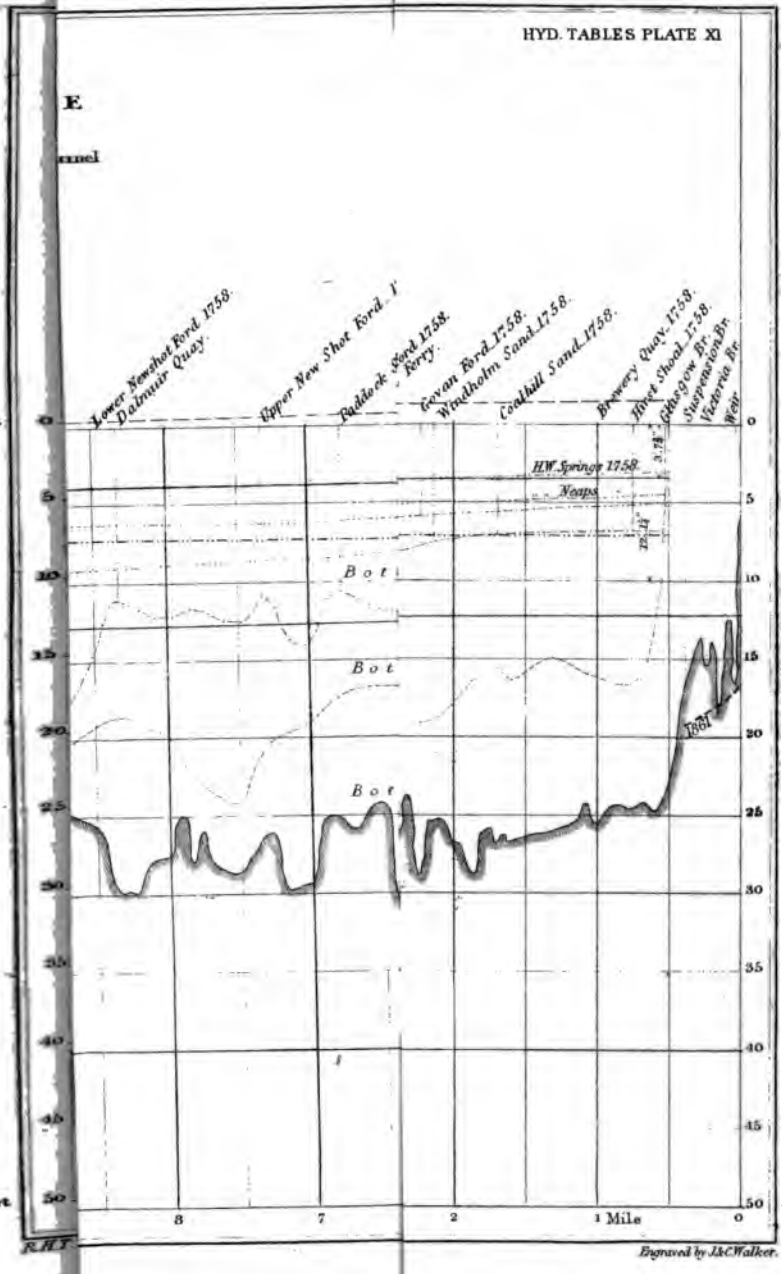
HYD. TABLES PLATE XI



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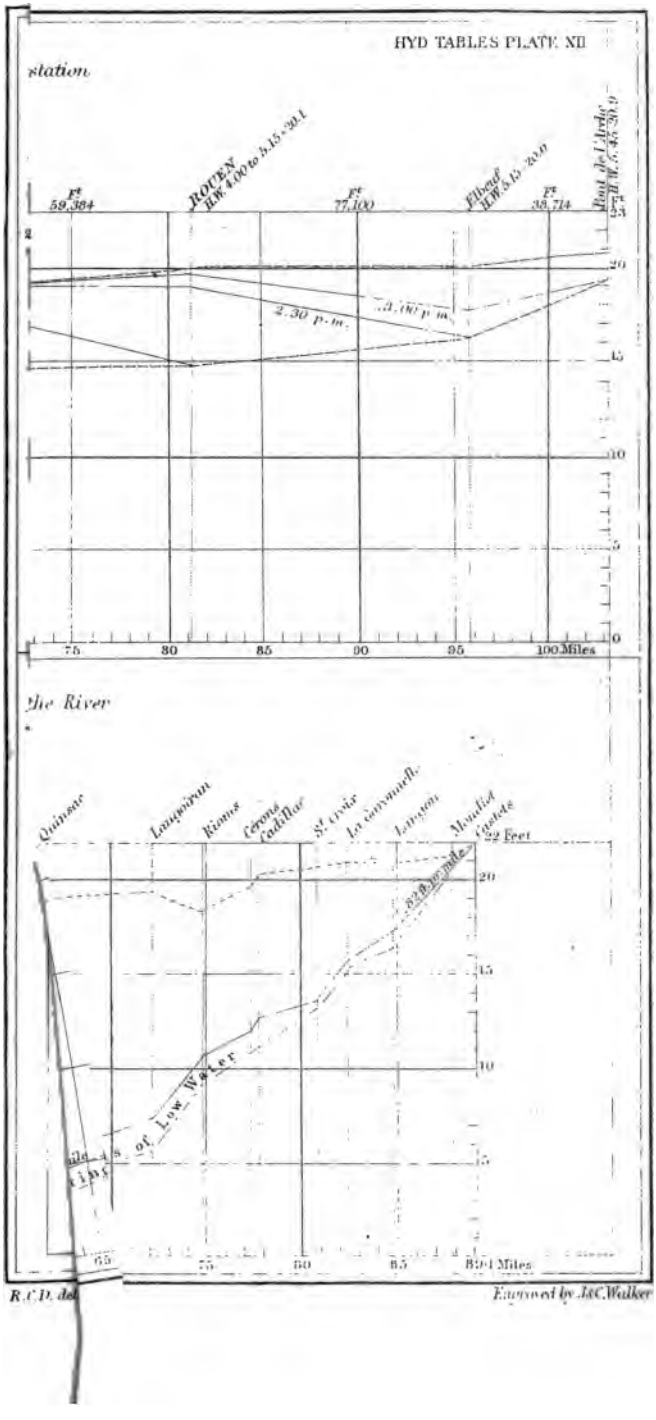
Station
ROUEN
H.W. 4.00 to 8.15 - 20.1
Ft 59,384
Ft 77,100
Elbeuf
H.W. 5.15 - 20.0
Ft 38,714
Pont de Claves
H.W. 5.45 - 20.0
2.30 p.m.
3.00 p.m.
75
80
85
90
95
100 Miles
The River
Quinare
Longueran
Rioms
Ceraud
Cadillac
St Croix
La Gavanelle
Lerasson
Moudlid
Cadede
22 Feet
82 Bx mide
of Low Water
65
75
80
85
85-1 Miles
R.C.D. del.
Engraved by J&C.Walker

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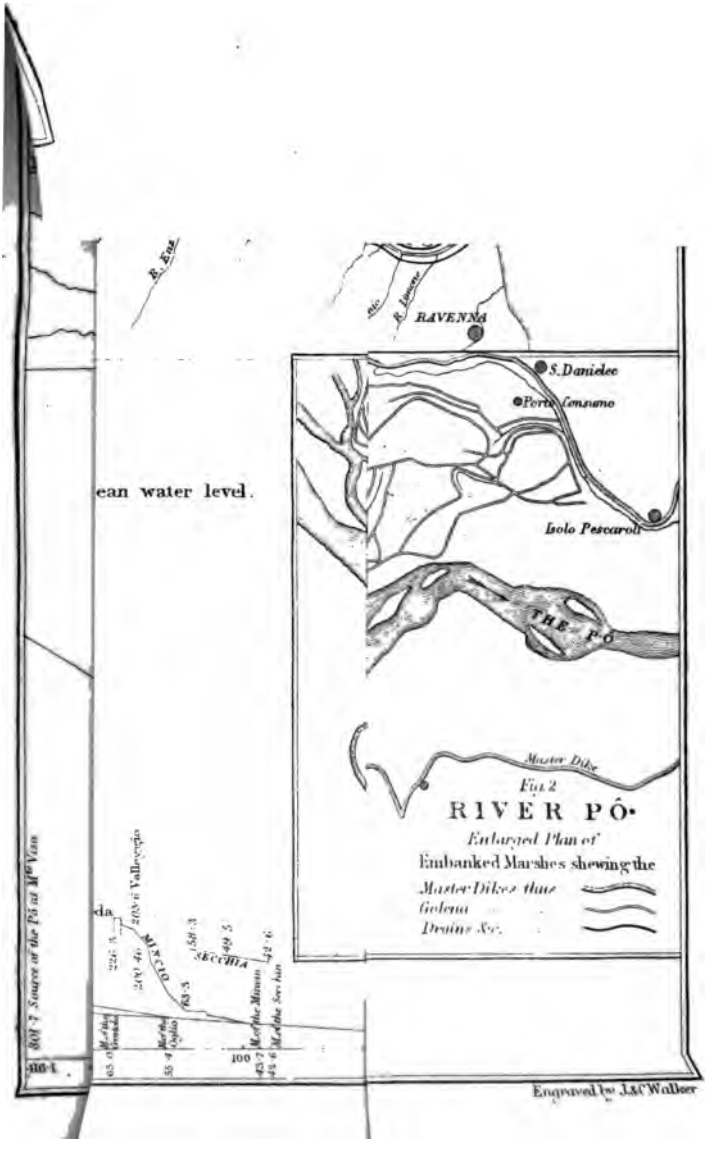
R. Po
R. Lamone
RAVENNA
S. Danielee
Porto Lemene
Isolo Pescaroli
THE PÔ
Master Dike
Fig. 2
RIVER PÔ.
Enlarged Plan of
Embanked Marshes shewing the
Master Dikes thus
Goleni
Drains &c.
ean water level.
da
MAGNOLO
SECCHIA
100
Engraved by J.&C. Walker

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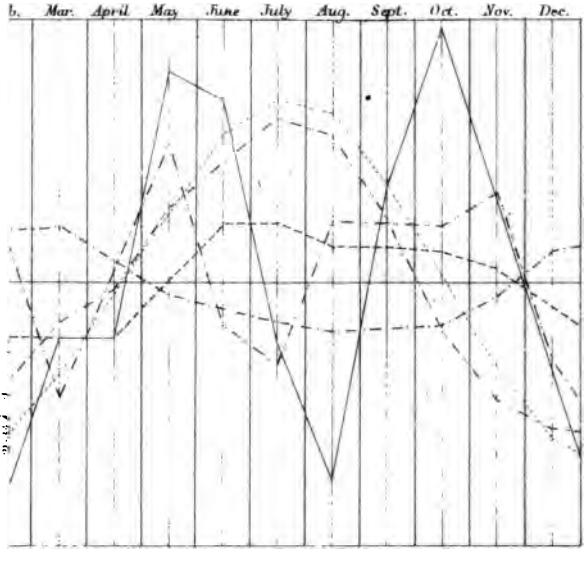
Fig 4.

...ram shewing mean monthly Discharge of the Pô, the Adda, & the Seine,

...pared with the mean rainfall, evaporation and temperature in Lombardy



G.K. Ch...

Engraved by J. & C. Walker

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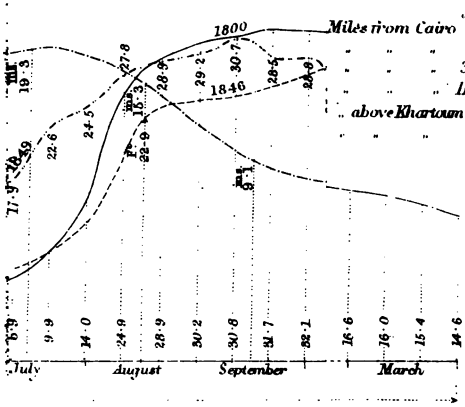
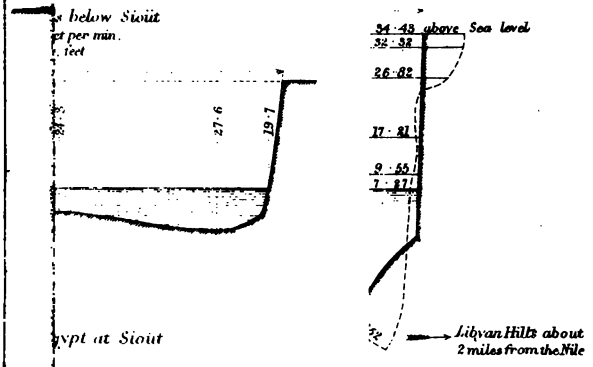
HYD. TABLES PLATE XV



Zëïd



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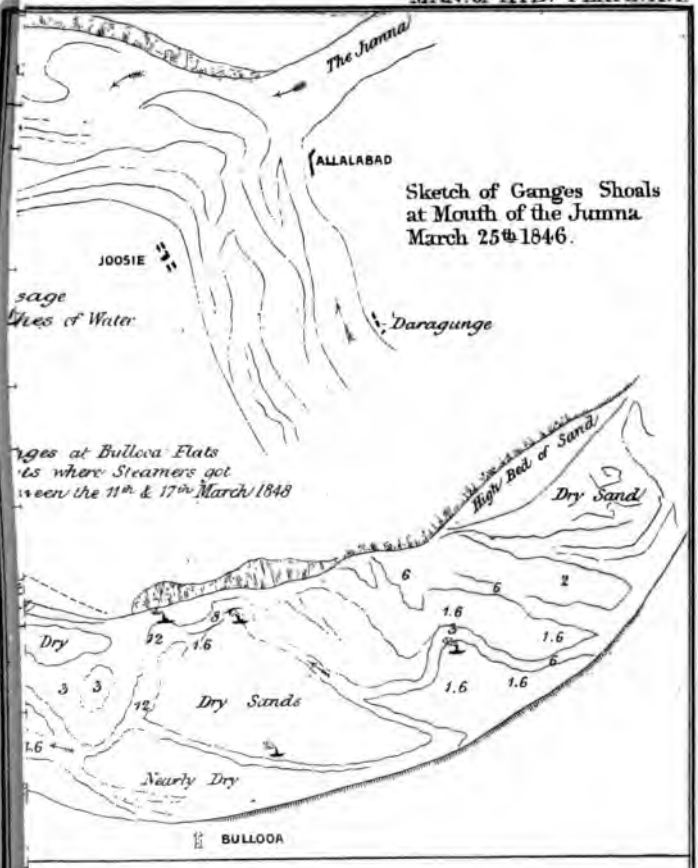
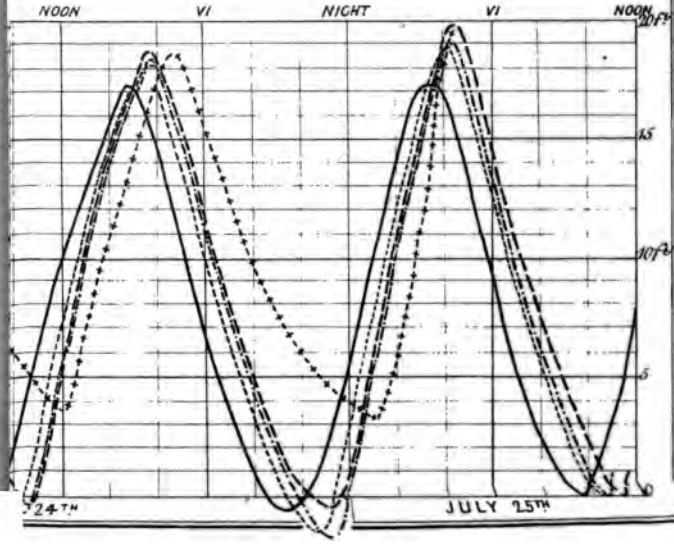

The Jumna
ALLALABAD
Sketch of Ganges Shoals
at Mouth of the Jumna
March 25th 1846.
JOOSIE
sage
Daragunge
ges at Bulloca Flats
ts where Steamers got
ween the 11th & 17th March 1848
High Bed of Sand
Dry Sand
Dry
Dry Sands
Nearly Dry
BULLOOA


57
NOON
VI
NIGHT
VI
NOON
20 ft
15
10 ft
5
0
24TH
JULY 25TH

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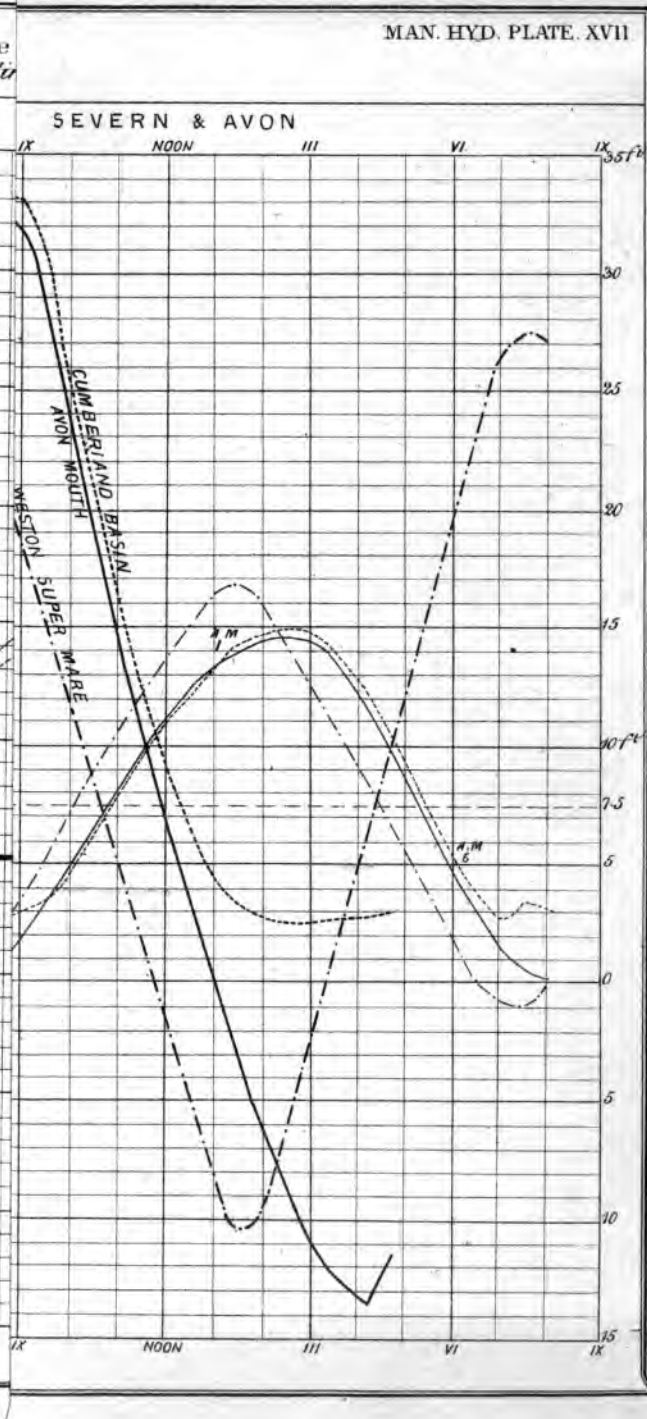
MAN. HYD. PLATE. XVII



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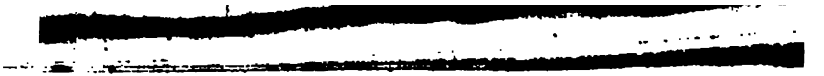

WESTLEYS
&Co
LONDON